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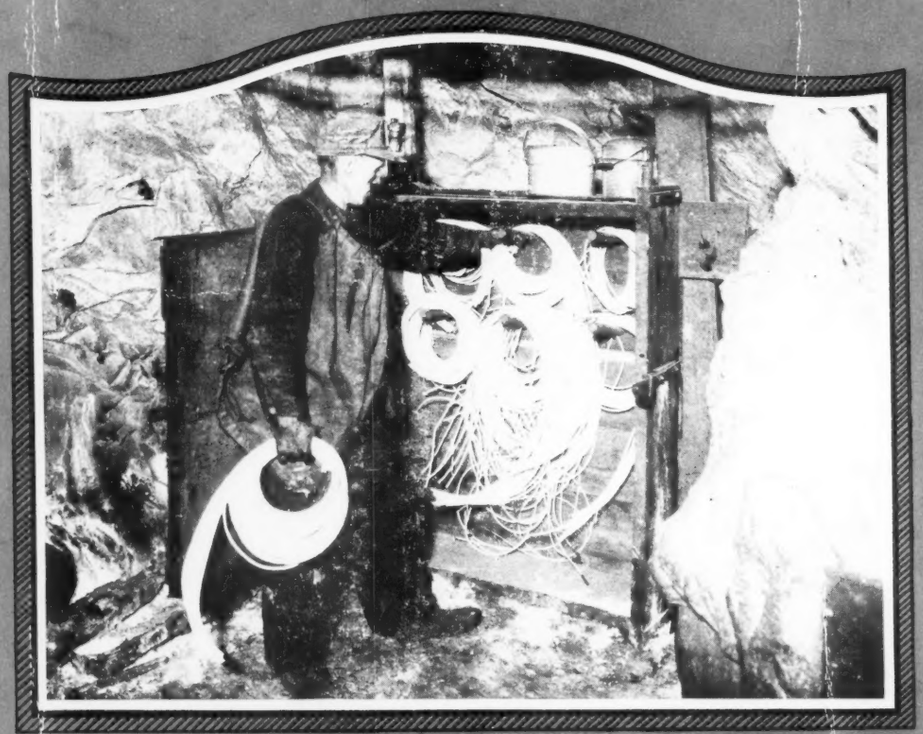

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Northern Rhodesia Very Rich In Copper
Owen Letcher

Cat Canyon Unique in California Oil Fields
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Refrigerator Car Works Wonders For Our Bodily Good
A. S. Taylor

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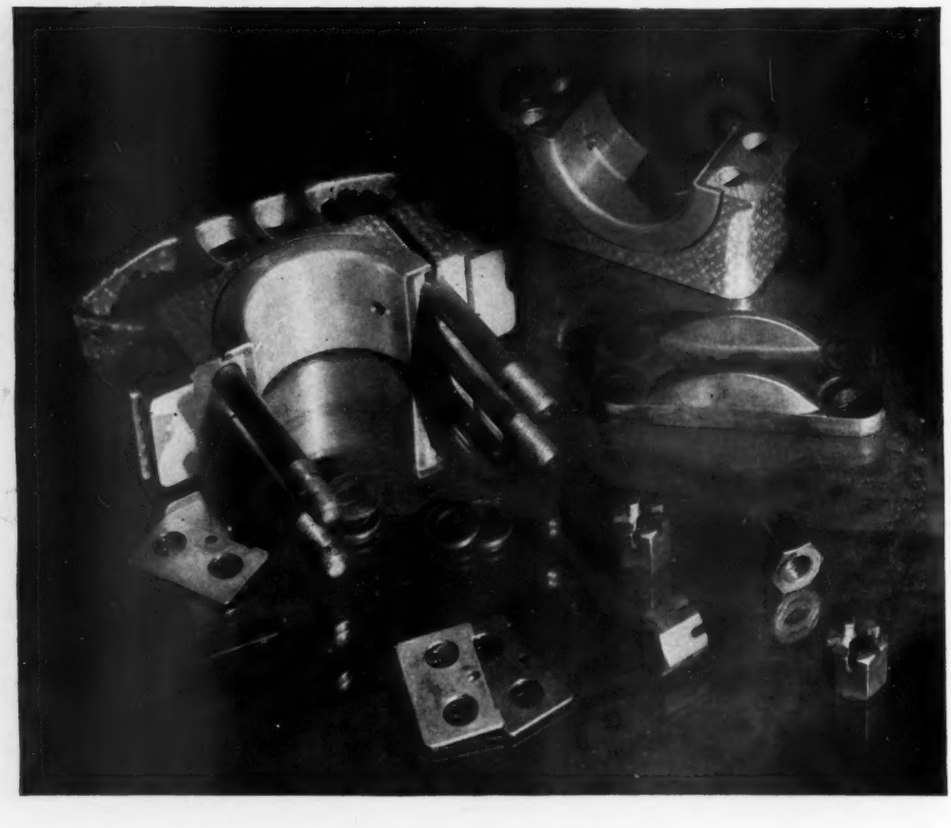

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Northern Rhodesia Rich in Copper

Something About the History, Geology, and Development of The Big-Tonnage Mines in That Region

By OWEN LETCHER

NORTHERN Rhodesia is at present producing approximately 7,000 tons of copper per annum from one mine only—the Bwana M'Kubwa. This output is insignificant, and affords no criterion whatever of the copper-yielding potentialities of the territory. A huge program of development, equipment, and railway construction is now being evolved, and when this is completed in about four or five years' time the country will be supplying 150,000 tons of copper annually. A few years later, probably by 1936, the output is likely to be 200,000 tons and more.

For the United States, Northern Rhodesia is of especial interest not only because the United States is today the world's greatest copper-producing and copper-consuming country but because much American capital is being invested in this African copper belt and many American mining men are being employed in the working out of the program. Besides, much American machinery is already being used there and still greater quantities are to be installed. Therefore, a brief description of the country and of its copper mines should prove of interest.

Roughly speaking, Northern Rhodesia lies between the watersheds of the Zambesi and the Kongo rivers. It has an area of 287,950 square miles and a native population of 1,140,642. The white population is very meager—no more, perhaps, than 8,000; but under the urge of mining development the number of "pale faces" is steadily increasing and, within the next few years, is likely to total 40,000 or 50,000.

Northern Rhodesia is completely land locked. The present outlet for her products is Beira in Portuguese Mozambique on the Indian Ocean. The country is linked with Beira and with the railway systems of Southern Rhodesia and the Union of South Africa by a line which traverses the territory from Victoria Falls, the magnificent southern gateway of the colony, to Sakania on the Kongo border to the north. A line penetrating Angola is now being carried into the Kongo. This is known as the Benguella Railway, which will give access to Lobito Bay, probably the finest harbor on the west coast of Africa.

Twenty years ago I roamed this territory shooting big game; scribbling articles with a spice of adventure in them; taking photographs and now and then trying to do a bit of prospecting. But ordinary prospecting in this country is a heart-breaking job because outcrops are mighty few and far between Still it was a great life until blackwater fever laid me out and sleeping sickness killed the few white men I met on my travels. At that time, I suppose I could have acquired for a few thousand pounds properties which are today valued at millions!

But as I have already remarked, prospecting in this territory is, generally speaking, a most futile job because the country is so densely bushed and wooded, and long, rank grass rises everywhere waist and sometimes helmet high above the soil. Nevertheless, minerals had been found in Northern Rhodesia ten years before I entered the territory. More than a century ago, Portuguese traders had referred to the "green stones" of copper that lay around the headwaters of the Kongo and the Zambesi. Livingstone wrote of this mineral wealth; and it is known that over a long period of history, perhaps for centuries, natives—working either independently or under Arab taskmasters—had been winning copper from rich deposits in what are now known as the territories of Northern Rhodesia and the Katanga Province of the Belgian Kongo.

But it was not until Cecil John Rhodes—the Empire Builder, with his eyes on the north, had brought the whole of present-day Rhodesia under the domain of the British flag, that any serious attempt was made to turn this mineral wealth to advantage. On June 27, 1890, Lewanika, paramount chief of the Barotse, signed an agreement with Captain Lochner, the emissary of Rhodes, granting to the British South Africa Company the sole mining and commercial rights over the entire region under his jurisdiction. Under this concession the chief recognized the protection of the British Crown, while his constitutional authority over his tribes was defined and safeguarded. Finally, at the end of the last century, a definite move was made in the direction of actually locating mineral wealth.

In the intervening years very little had been done by the chartered company in the way of exploring the mineral resources of the territory; and, although traders and missionaries had brought down reports and specimens which led to the belief that minerals of commercial value existed south of the Kongo Free State, the first properly organized expedition to North Western Rhodesia, as it was then called, did not materialize until the year 1899.

In that year the late George Grey, at the request of Cecil Rhodes and Robert Williams, led an exploring party from Bulawayo for the purpose of locating various concession areas granted to subsidiary companies by the chartered company. This expedition failed to find indications of minerals in payable quantities on the southern part of the plateau between the Kafue River, on the west, and the Loangwa, on the east; but promising indications of mineral wealth were discovered at the headwaters of the Kafue, Lunga, and Mombije rivers adjoining the Kongo watershed. This area now constitutes a section of the great copper belt of Northern Rhodesia.

The George Grey expedition located the Kansanshi copper mine where extensive disused workings, some thousands of feet long, were found in parallel runs, indicating the existence of continuous vertical fissures.

Top—Officials, engineers, and native villagers watching the laying of the first rails of the Lobito Bay line where it enters the Kongo. Left—Caterpillar tractor hauling timber and native boys at the N'Kana Mine. Right—Examining cores taken from bore holes made in the copper fields of Northern Rhodesia.

The Kansanshi Mine was discovered by means of native information on September 6, 1899; and, in addition to its copper content of 4¼ per cent, was found to contain 4½ pennyweights of gold per ton. George Grey, a brother of Viscount Grey of Falloden, was a born leader of men who loved adventure for adventure's sake. After finding the Kansanshi Mine he explored Katanga and located many of the huge deposits which are today being so successfully worked by the Union Miniere. Poor Grey was killed by a lion when hunting in Kenya in 1910.

From 1900 onward a number of exploration companies was formed under the aegis of Messrs. Percy Tarbutt, Edmund Davis—now Sir Edmund, and the chartered company. Many of these are now defunct. The Northern Copper (B. S. A.) Company, however, actively developed a number of copper lodes, traced through ancient workings, including the Silver King, Sable Antelope, Blue Jacket, and others on the Kafue River to the west of what is now Broken Hill. Many of these held out prospects of becoming mines of importance. The Rhodesia Copper Company was another associated company, under the same control, which undertook active development operations on a considerable scale.

It was in 1905 that W. C. Collier, a well-known Northern Rhodesian prospector, found the Bwana M'Kubwa Mine a few miles to the south of the Kongo border; and a little later he located the Roan Antelope which has been floated into a large company under Chester Beatty and is likely to become one of the world's great copper mines. Bwana M'Kubwa, in the Kiswahili language, means "Big Master". At this mine was a very pronounced malachite outcrop from which natives and Arabs had excavated many tons of high-grade ore. The Northern Copper Company did some work on Collier's discoveries; but in those days the railway had not advanced very far north of the Victoria Falls, transport was a tremendous problem, and the country was regarded more as a field for the big-game hunter than for the industrialist.

In pursuance of Rhodes' Cape-to-Cairo dream, the railway was pushed on, and in 1906 it reached the Broken Hill zinc and lead mine which had been discovered by T. G. Davey a year or two previously. In 1910 the Northern Copper Company floated off Bwana M'Kubwa as a separate enterprise. It was not, however, until 1922 that any really extensive development of the Northern Rhodesian copper belt was attempted.

During all those years the big Belgian mining company, the Union Miniere du Haut Katanga, had been developing and equipping the amazingly rich copper deposits that lay on the other side of the frontier; and by 1922 the company had attained a production of 43,000 tons of metal. During that year, Preston K. Horner—an American mining engineer who had for some time been general manager of the Union Miniere in Katanga—induced Chester Beatty, the Minerals Separation group, Sir Edmund Davis, and others to make a really forward movement in regard to Northern Rhodesian copper. Horner's experience on the Belgian side of the watershed had led him to believe that there was more copper in Northern Rhodesia than was thought to be the case. But this copper was buried under an overburden, and the whole mineral belt was concealed by the rank grass and the forests of South Central Africa. A start was therefore made at Bwana M'Kubwa; and at the same time was organized a concern styled Copper Ventures, Ltd. This company obtained an option on the N'Kana Mine and a concession to an area of 2,000 square miles surrounding this property.

In January, 1923, the British South Africa Company granted to Copper Ventures, Ltd., a concession to 52,000 square miles in the extreme northern section of North Western Rhodesia. There the Rhodesian Congo Border Concession, Ltd., commenced prospecting three months later. The Mufulira Mine was shortly afterwards found in the N'Kana Concession; and in January, 1924, the Bwana M'Kubwa company acquired the N'Kana Mine and concession.

In 1926 the Anglo-American Corporation of South Africa acquired large interests in Northern Rhodesia, and subsequently assumed technical control of many of the mines. About the same time the Loangwa, Kasempa, and Serenje concessions were formed. In that year the N'Changa discovery, made by the Rhodesian Congo Border Concession, Ltd., was floated off as a separate enterprise under the title of N'Changa Copper Mines, Ltd.; the M'Tuga Mine was acquired by the Falcon Company; Bwana M'Kubwa commenced production; and Chester Beatty's Selection Trust, Ltd., took a hand in the exploration of the N'Kana Concession.

In 1927 exploration of the N'Kana, Roan Antelope, N'Changa, and other copper mines was continued—the Roan Antelope being floated in June of that year. The principal events in 1928 were the amalgamation of the Loangwa, Kasempa, and Serenje concessions and the general intensified prospecting and development operations. A big plant was decided upon for the Roan Antelope; and the Rhodesia Anglo-American Corporation was formed. In January of the same year the well-known financiers S. B. Joel and Sir Ernest Oppenheimer and party visited Northern Rhodesia. A sharp advance in share prices was recorded, and a great wave of optimism as to the future of the copper industry swept over South Africa.

These are the outstanding chronological features of the development of the Northern Rhodesian copper industry. It has been necessary to portray them in proper sequence in order to make clear the situation as it is today and to show how matters gradually have developed. The background of the drama is the South Central African bush, with here and there its little *kraals* or villages invariably built alongside a stream. Into this territory the white man is forcing his way with his steam shovels, concentrators, and smelters. But along the copper belt you may still hear the hunting "whoof" of the lion or see the striped body of the zebra swallowed up by the eternal forests.

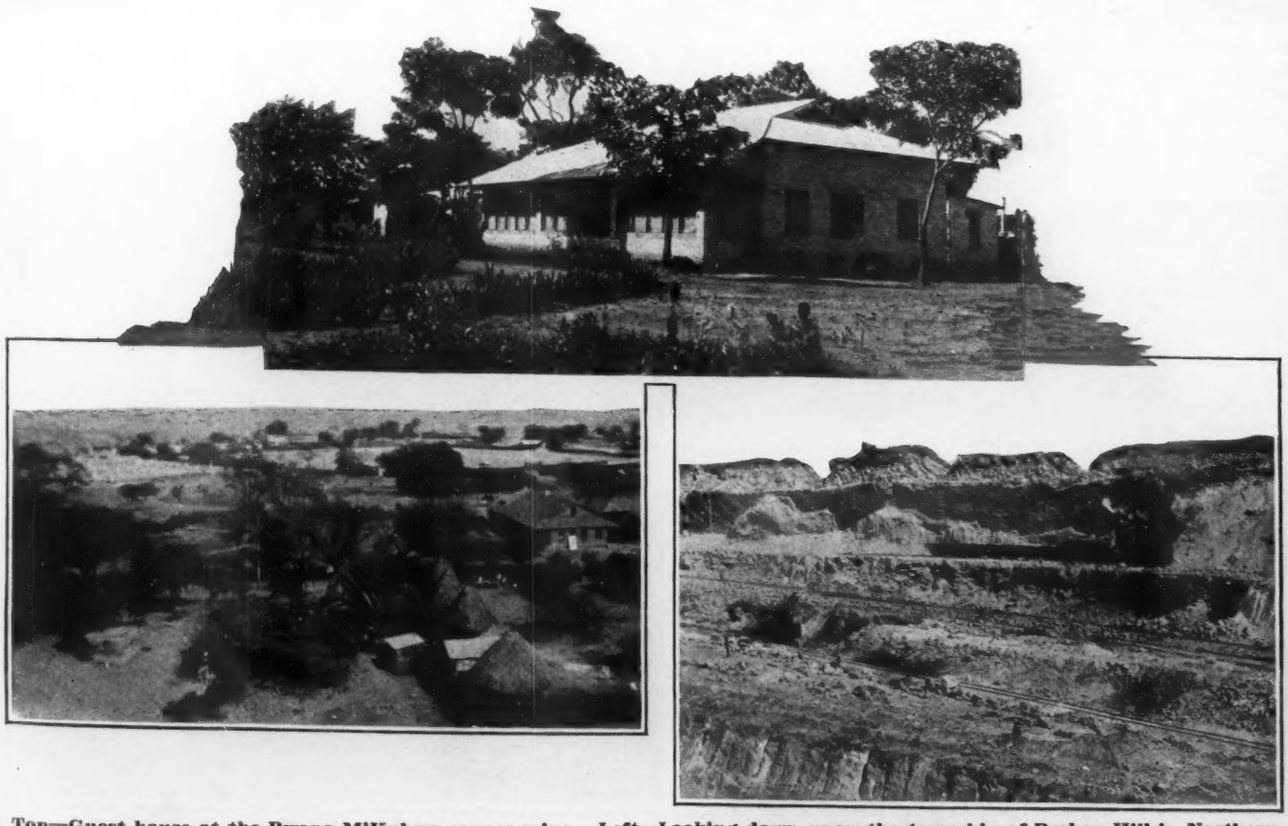
The increasing output of the Union Miniere in the Kongo, and the confirmatory reports from many leading engineers as to the copper wealth of South Central Africa have induced American capitalists to venture into this new realm of copper. It is an open secret that they made a bold bid for control of the Union Miniere, a move that did not succeed.

Into the service of this great mineral belt are being enlisted the brains and the brawn of a number of American mining engineers and metallurgists. Among these are D. D. Irwin, formerly of the Phelps Dodge Corporation, R. G. Parker, Peterson, and Marcellus who have had wide experience in Montana, Utah, and other big copper districts of the United States. These men are busy at the Roan Antelope and the various other properties controlled by the Rhodesian Selection Trust. Thorold Field and Doctor Sussman have recently reported on the properties; and a leading American copper metallurgist, Mr. McGregor, is at work in London on the details of a big concentrator and smelter plant that is to be installed at the Roan Mine. The Roan Antelope Company's program, alone, entails the spending of more than £3,000,000 sterling on development and equipment. Already large sums have been paid for the plant; and American machinery firms have executed orders which, in the aggregate, run into very large figures.

A short statement as to the outstanding geological and technical aspects of the field, with a reference to the essential differences between the Northern Rhodesian copper mines and those of Katanga, may not be out of place here. The differences between the deposits of the mines belonging to the Union Miniere group and those of Northern Rhodesia are fundamentally those between surface and deep-seated occurrences, between oxidized and sulphide ores.

The deposits of the Belgian Kongo consist almost entirely of malachite, azurite and chrysocolla—deep mining being practically unknown in the Katanga except in one or two instances, such as at Kipushi, almost on the Rhodesian border. In the majority of the Kongo deposits there are no indications of the continuity of cupriferous deposits in depth. Furthermore, the deposits are scattered over a wide area, which necessitates the building of several separate treatment plants and the construction of lengthy lines of transportation which do not make for the most economical working conditions.

In Northern Rhodesia, on the other hand, surface indications of the enormous deposits that lie beneath the bush and *dambos* are comparatively few, but the depth to which



Top—Guest house at the Bwana M'Kubwa copper mine. Left—Looking down upon the township of Broken Hill in Northern Rhodesia. Right—The expansive pit of the Bwana M'Kubwa Mine.

Celebrating the first shipment of Kongo copper to be exported by way o. the west coast.

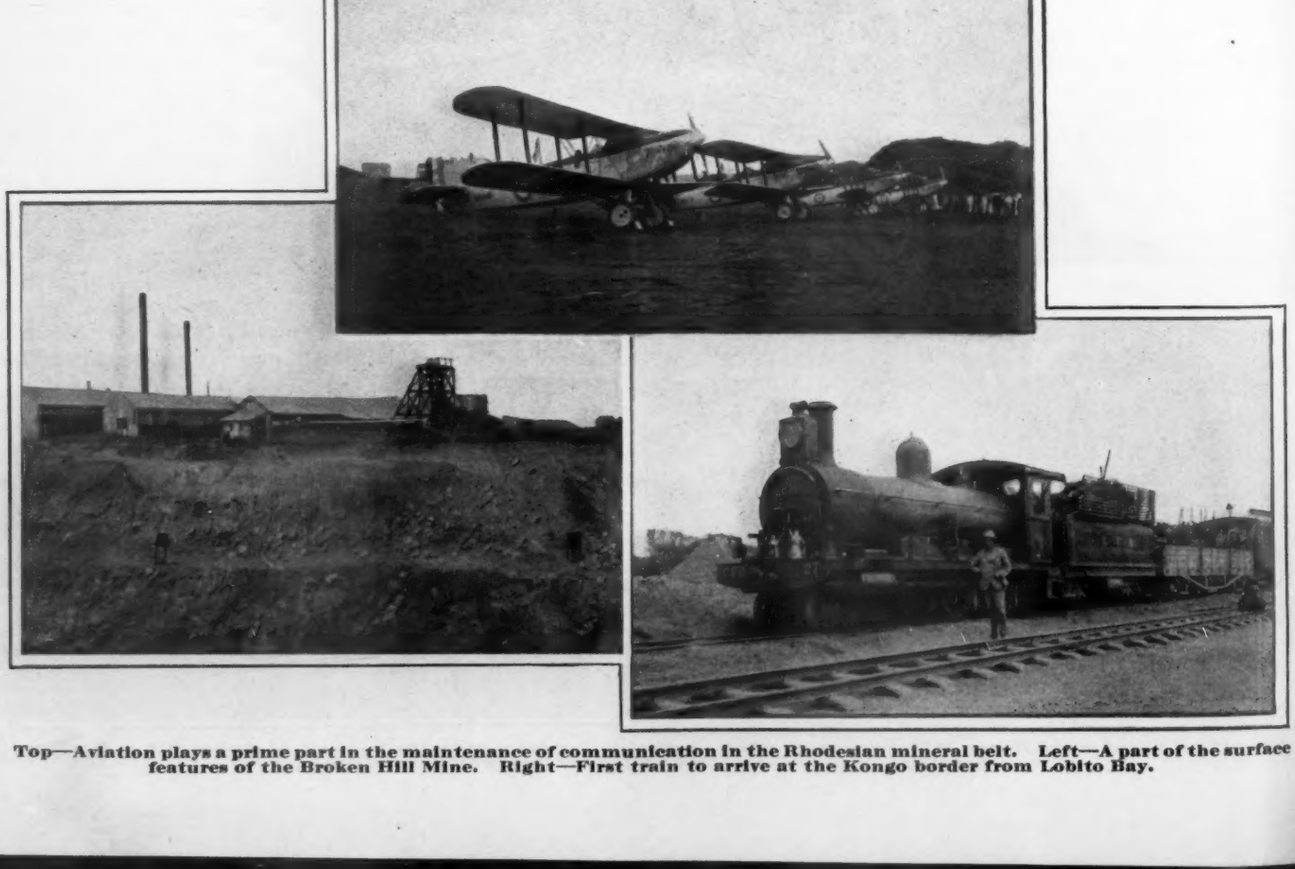
they go and the continuity of their strike demonstrate the existence of deposits of colossal dimensions. The most important mines discovered there so far—the Roan Antelope, Bwana M'Kubwa, N'Kana, and N'Changa—are all situated fairly close to the border. So, too, are Mufulira, Chambishi, and other promising prospects. To the south and west evidences of copper mineralization have been observed over an area more widespread than any heretofore found in a territory of corresponding size. And it might be added here that the proximity of the four largest mines makes it possible for them, unlike the workings of the Union Miniere to the north, to employ communal treatment plants and central smelters.

The copper belt consists of a strip within 50 miles of the Kongo border and stretching from Bwana M'Kubwa on the east to Mwinilunga on the west. In this area, Bwana M'Kubwa is producing at the rate of from 500 to 600 tons of copper per month. Several other mines are being developed and equipped, and there is every reason to believe that they will be in time among the world's largest producers. Besides, there have been made at least twenty fresh discoveries in the last few years. These are now receiving attention, and a proportion of them may be expected to develop favorably. In every case the deposit is similar—that is to say, it is of copper minerals impregnating a sedimentary rock. At Bwana M'Kubwa, N'Kana, and N'Changa the rock is a sandstone: at the Roan Antelope it is an indurated shale. At Bwana M'Kubwa and Kansanshi the copper mineral, down to 100 feet at least, is carbonate, while at the Roan Antelope carbonates are almost entirely absent and sulphides predominate at the surface.

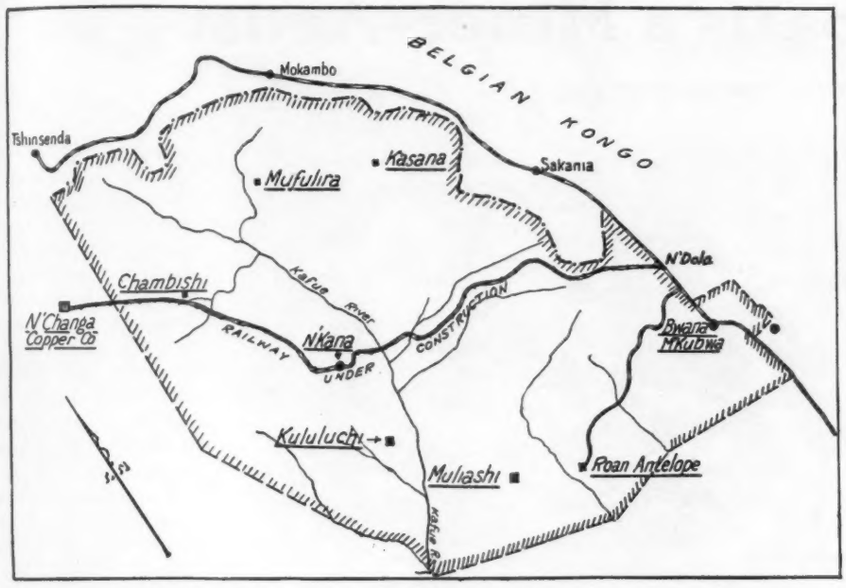
In every instance, the sedimentary copper-impregnated bed appears to occur in the leg of a syncline formed by the folding of the sedimentary beds by granite rocks which have actually enfolded them in the massive granite or gneissic basement. At the Roan Antelope and at N'Changa, for example, the syncline can be followed round the end, and by bore holes across the foldings. Again, at Bwana M'Kubwa only one leg or portion of a leg is exposed, and the syncline has to be surmised. In no case is an anticlinal fold exposed: such folds seem to have been removed by denudation, leaving only the troughs embedded in the gneissic basement.

In only two instances so far discovered, at Bwana M'Kubwa and Kansanshi, do the deposits make a physical feature by standing up above the general level of the country. Elsewhere the general level of the country is preserved; and discovery of the ore has been due either to the absence of bush on the outcrop or to carbonates noticed in stream beds. In just one case can the outcrop be traced on the surface to its true determination. This is at Bwana M'Kubwa, where the outcrop of the chute is exposed by nature from end to end. All the other actual exposures are very small, just appearing through the laterite crust which covers the whole country.

With the exception of Bwana M'Kubwa



Top—Aviation plays a prime part in the maintenance of communication in the Rhodesian mineral belt. Left—A part of the surface features of the Broken Hill Mine. Right—First train to arrive at the Kongo border from Lobito Bay.



Where Rhodesia is outstandingly rich in its deposits of copper.

and Kansanshi, and to a lesser degree Konsonso, there do not seem to be any rich secondary deposits of malachite, similar to those in the Kongo, in veins in the Northern Rhodesian beds. At the mines mentioned they have been exhausted; and deposits in this area will have to be worked in future on the normal copper content of the impregnated bed.

With regard to the economic aspects of the beds, it appears that they are in all cases extremely uniform in grade, running from 3 to 5 per cent metallic copper over a width of anywhere from 30 to 100 feet and more. Such being the case, any one of the properties now being developed may be estimated to contain immense tonnages of ore.

Details of the metallurgical treatment of the Northern Rhodesian ores, so far as the Roan Antelope-Selection Trust groups are concerned, are now being worked out in London and in New York. At Bwana M'Kubwa a plant designed by Metals Production, a subsidiary of Minerals Separation, has been at work now for nearly three years, and this installation—which is of somewhat novel type—has been found suitable to the class of ore treated. Both the Roan and N'Kana mines are being laid out with a view to supplying 5,000 tons of ore per day and of producing 50,000 tons of copper per annum, while N'Changa, Mufulira, Muliashi, and Kansanshi between them may yield as much as 100,000 tons of metal in the not far distant future. Some idea of the great potentialities of this South Central African copper belt may be obtained from a contemplation of the present ore reserves and tonnages indicated by drilling.

In Northern Rhodesia, even at this early stage, the presence of something like 66,000,000 tons of ore is indicated in but three mines—the Roan, N'Kana, and N'Changa. This ore, on an average, will contain little less than 4 per cent of metal, or approximately 2,500,000 tons worth £187,000,000 at today's prices.

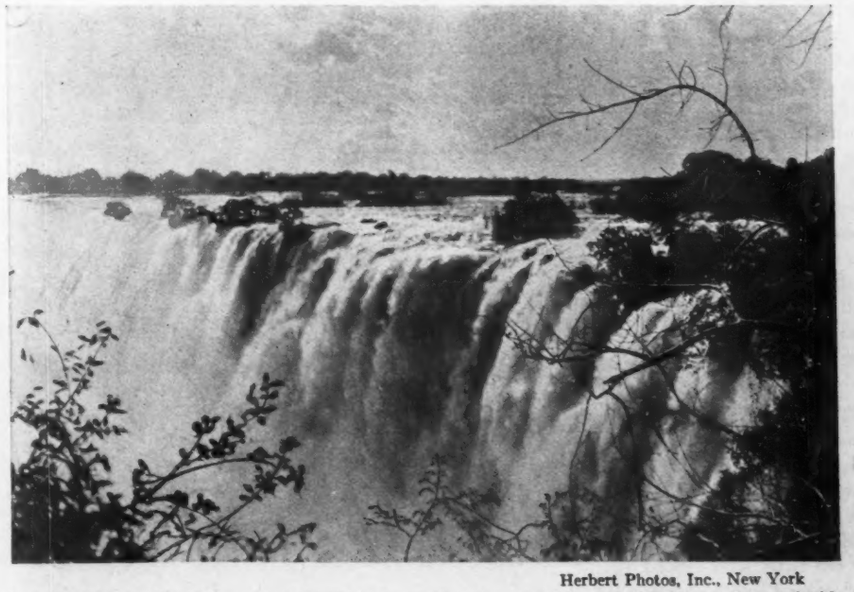
The latest statement available with regard to the Union Miniere's reserves is for the end of the year 1927. At that time the Union Miniere had in reserve 78,491,000 tons of ore averaging 6.93 per cent copper, or, in other words, 5,439,000 tons of metal. At the present quotation of £75 per ton, this represents a gross value of no less than £408,000,000. Compare these figures with the payable gold reserves of the Rand, aggregating perhaps 110,000,000 tons of ore with an average value of 6½ pennyweights of gold per ton and worth about £150,000,000.

Mineral development in Northern Rhodesia cannot fail to have an important influence on the whole railway system of the territory, and it may quite conceivably have large and vital repercussions on the transportation problems of adjacent territories as well. The focal point of the whole transportation system of South Central Africa is the Katanga Province which, by virtue of being more developed than Northern Rhodesia—its copper industry is several years ahead of the British copper industry, is the center from which railways radiate toward the four points of the compass.

For years past there has been a fear that the availability of other systems would throw into comparative insignificance the Rhodesian railways north of Wankie, and especially if the Belgians should render themselves independent of the coal fields at Wankie through the large-scale electrolytic leaching of their copper ores and, perhaps, the electrification of their railways.

The development of a huge base-mineral industry in Northern Rhodesia will, however, compensate for the loss of the Kongo trade. But it must not be overlooked that the American copper interests in the north—as distinct from the groups which are more closely identified with the chartered company—are already looking toward the Atlantic seaboard and Lobito Bay as the most expeditious and economical method of dispatch and importation. Whether the Wankie coal fields will bind them to the southern route or not, that remains to be seen; but it is clear that the Rhodesian railways and the Port of Beira will have to make freightage attractive if all the copper concerns in the north are to continue to export copper and to import machinery and supplies via Rhodesia's ocean terminal on the east coast.

The Northern Rhodesian fields already have developed to such an extent that one branch line from N'Dola to the Roan Antelope Mine has been completed and the construction of another railway from N'Dola to N'Kana has been commenced. Extensions of these and other new railways will be undertaken as further development may dictate.



Herbert Photos, Inc., New York

This photograph of the crest of Victoria Falls gives no hint of the sheer drop of 400 feet which the Zambesi River makes at this point on its long journey to the Indian Ocean.

Butte Boasts a Miner-Artist

By A. J. CLARK

SQUARE pegs in round holes; round pegs in square holes; and pegs that won't fit any hole. Human society has been troubled with all these ever since man first responded to an urge towards higher and better things. The problem has become still more acute in these days of intense competition owing to the nearly universal desire to stand on a more favorable plane, measured in terms of material things. Sociologists are devoting a lot of time and a good deal of other people's money trying to devise ways to find the right hole into which to fit the peg that would best conform to it. Our little story is about still another kind of peg—a peg that has managed to fit itself into more than one hole usefully while exercising a native bent that will eventually qualify him for a "better 'ole"—we refer to the young man who made the sketches that adorn our text, sketches that give graphic evidence that willingness to work and to achieve can do wonders in overcoming difficulties.

Early day pan miner.

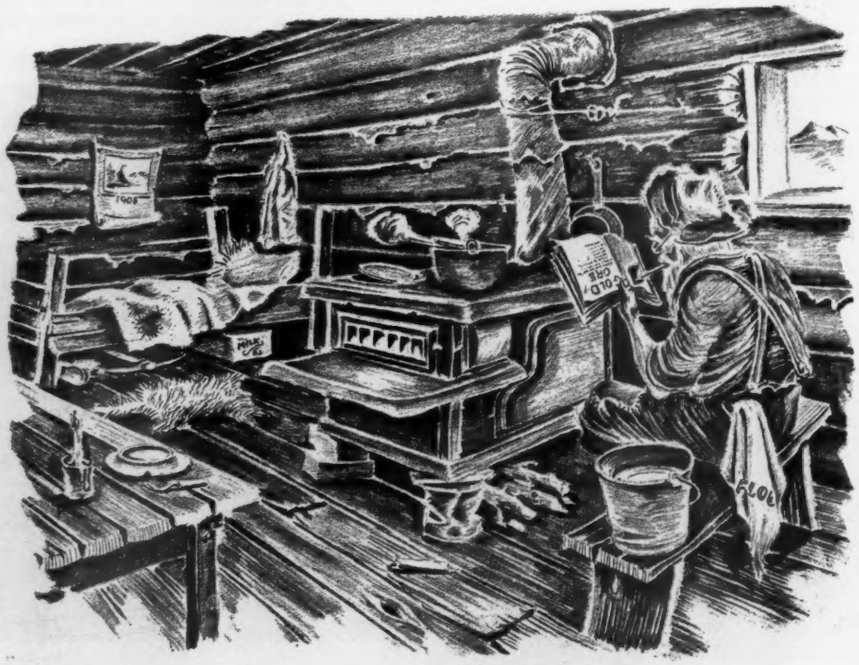
One would scarcely turn to a hard-fisted miner to find a hand sensitively responsive to an eye alert to the picturesque in nature either above or below ground; and yet just such an adaptable person is now to be found in Butte, Idaho, toiling in the copper mines for his daily bread and spending no little part of his waking hours in registering on paper the things he sees and some of the things that adorn only his fancy. We speak of Robert Hall the miner, and the artist in the making. We shall let one of the youth's friends tell his story.

The art instinct, inherent in some few gifted people, worms itself out somehow no matter what the environment. Butte had until very recently an old man who looked and talked like a sheepherder but who could do things with a pen that no mere pen expert ever was able to accomplish; and the incongruity of beautiful scrolls and delicate scrivenings coming from such a source was always a cause for wonderment. The old man kept a sheaf of pens in his whiskers, and the legerdemain of pulling a "Medium Fine" or a "No. 2 Stub" from the recesses of his mattress added an extra charm to his penmanship.

We have now another freak of genius in the author of the drawings reproduced: a young man who might have come out of a cave with a lump of red clay—prehistoric. He blew into a Butte printing office two years ago, an ungainly young man in overalls who ran mostly to hair. He had a collection of drawings, more or less bad, that he was proud to show. He thought they were good; but, while they gave promise of talent, they were mostly bad.

The young man was persistent, and in two years he made surprising progress. With hands knotted and callosed from pick and shovel and the matter of mucking ten or twelve tons of rock a day, he has done things with a pencil that would put to shame many a more delicate personality—the art instinct is in him.

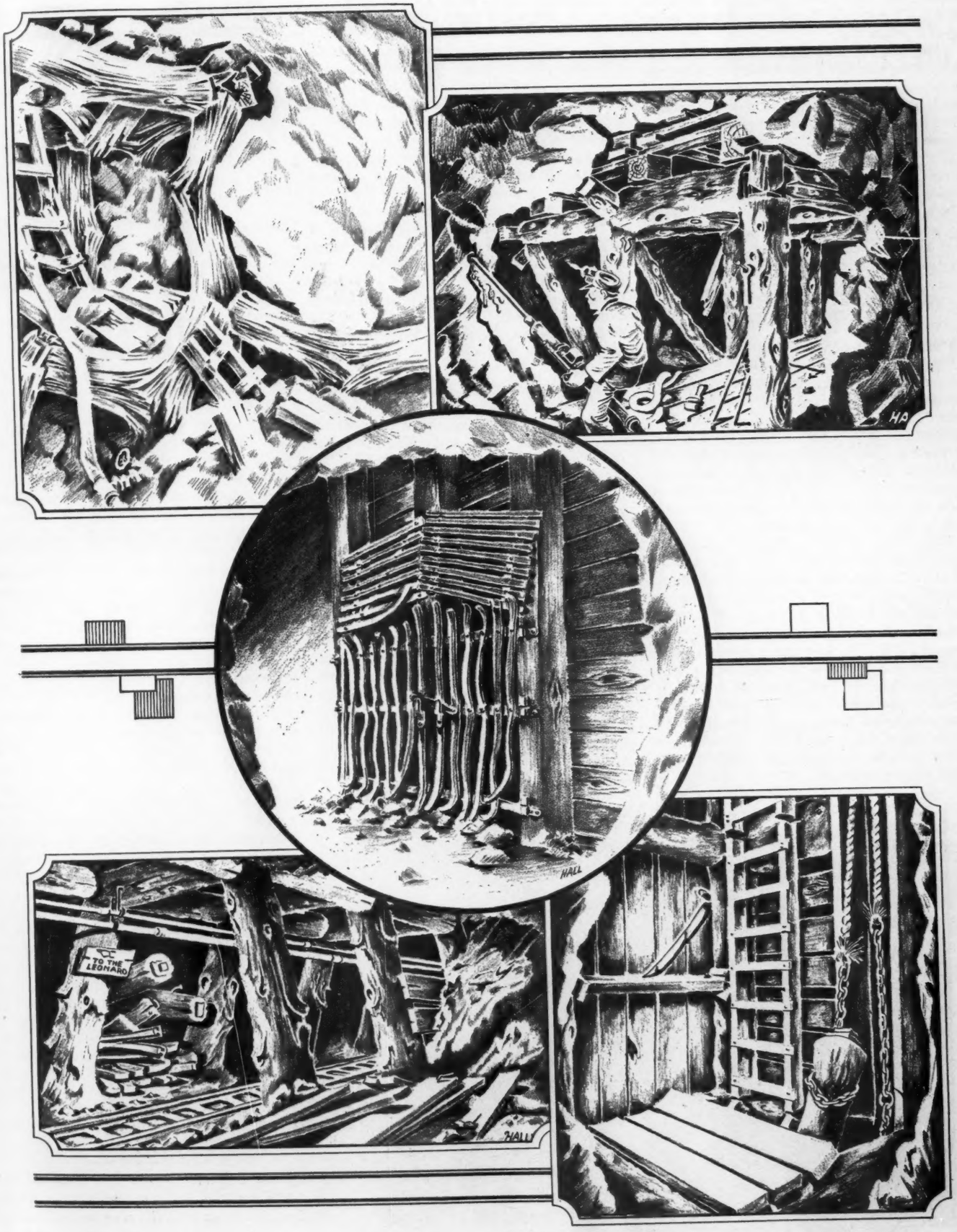
It appears that Hall is just a grown-up gamin who, as a kid, sold papers on the streets of Chicago, "skinned mules" for a construction gang at fourteen, a roustabout on a Stockton River boat, a "rigger chaser" in the Oregon woods where one hooked a cable to the end of a log and then followed it so it would not snag. For several years he has been a miner and a keen observer—clean, bright-eyed, and still hairy like a bear, a young man with a future.



Old prospector at home.

"Art is long" and slow of recognition. Our friend, Hall, has survived such disappointments and heartaches as come to most struggling geniuses. There have been days and days when tragedy followed him about and discouragement sat on his humble doorstep. There have been many times when he visited me, like a homeless dog, hungry only for some small crumbs of art and praying that the things he wanted to do might somehow come to fruition.

We are a selfish race. We seldom bother with the tribulations of our brother. We are slow with encouragement and stingy of our time. The struggling genius who humps his back for a



Top, left—An old manway, showing ground working against old timbers. Right—Driller making room for another set. Circle—Shaft gates after years of service. Bottom, left—Old-time drift in a Butte mine. Right—Hoisting timber in a Butte mine.

kindly pat, more often than not is rebuffed. We don't give him the comfort that we would give a yellow dog.

And so we have Robert Hall, who in the beginning was just a stray seed blown by the winds of chance to one or another barren place, with poverty and lonesomeness a heritage; and though street gamin, mule skinner, rigger chaser, laborer, and miner, all crowded into a paltry twenty years he has remained clean. From that careless seed. God only knows what flower or fruit may bloom and ripen. Just now, there is only a young man who has a vision. It would be a fine world if there were more like him—if some of us happily had sons who began as rigger chasers and remained clean.

AIR-DRIVEN SAW RECLAIMS MINE TIMBERS

THE amount of work that can be accomplished by a single air-operated machine as compared with manual labor is strikingly exemplified in the case of a portable pneumatic saw in use in one of the largest mines on the Central Witwatersrand in South Africa. It has been the practice at that mine to reclaim all broken timbers—such as stulls, props, etc., and to cut them up in different sizes for further service throughout the workings in the form of stope packs.

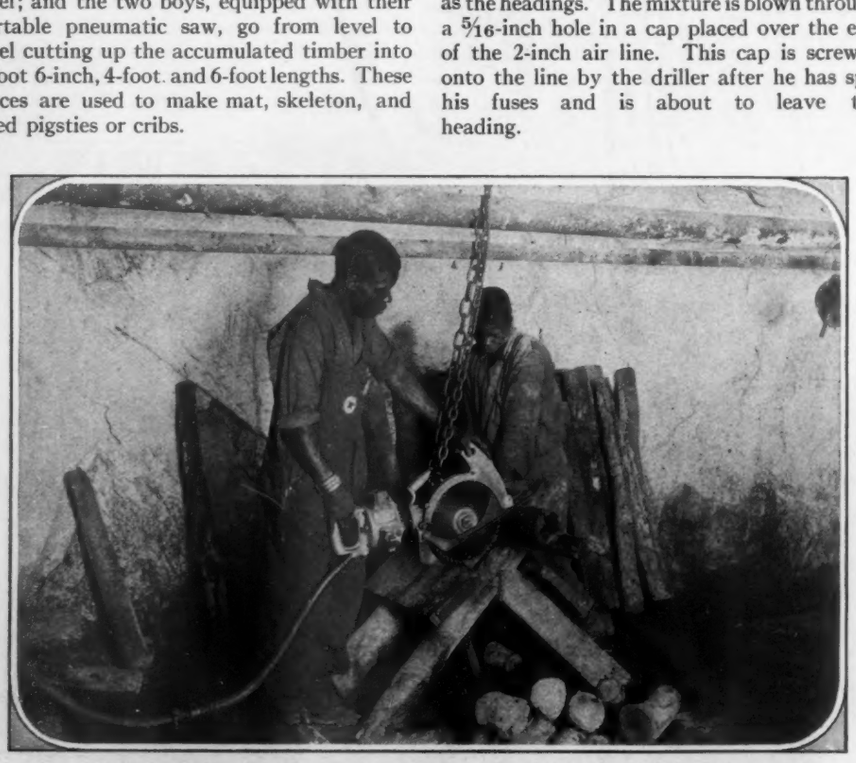
This salvage work was formerly done with hand saws and by nine gangs of two boys each at a total outlay for labor of about $15.30 per day. Now a B-12 safety-first air saw and two boys are able to do all the timber-reclaiming at the mine at a saving *per diem* of $13.60. To facilitate operations, there are three wood yards in the mine, one on each level; and the two boys, equipped with their portable pneumatic saw, go from level to level cutting up the accumulated timber into 2-foot 6-inch, 4-foot and 6-foot lengths. These pieces are used to make mat, skeleton, and filled pigsties or cribs.

COMPRESSED AIR AND WATER CLEAR HEADINGS

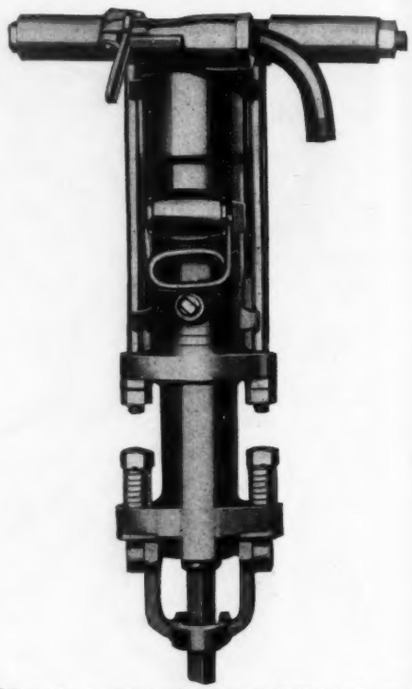
AT the Wright-Hargreaves mine, at Kirkland Lake, it is the practice of the machine men, so *Engineering and Mining Journal* informs us, to use a mixture of compressed air and water instead of just air to clear a heading of smoke and gases after blasting. To accomplish this, the water and the air lines are connected at a point some distance back from the heading. There a tee is inserted in the air line, and into this tee, at 90° to the line, is screwed a nipple on the end of which is a valve of the kind used for regulating the water for drilling machines. From this valve runs a 5-foot length of water hose terminating in another valve which connects with the water-supply pipe leading to the face. These two valves are kept closed except when the heading is to be cleared after blasting.

The procedure is as follows: When the machine man has finished drilling he turns off the air and the water supplies at the working face; loads the holes; and spits the fuses. Then he opens the two water valves just described, one of which serves as a check; leaves the heading; and turns on both the compressed air and the water at the aforementioned connection made some distance back from the face.

This arrangement requires that the water be maintained at a higher pressure than the air so as to force the water into the air line. This is done by using air at 95 pounds pressure and water at 125 pounds pressure—the difference being sufficient to carry the stream up into the stopes so as to clear them as well as the headings. The mixture is blown through a 5/16-inch hole in a cap placed over the end of the 2-inch air line. This cap is screwed onto the line by the driller after he has spit his fuses and is about to leave the heading.



One of three underground wood yards in a large South African mine. The portable pneumatic saw is carried from level to level and now does the work of nine hand saws.



New type of "Jackhamer" drill that comes in three sizes to suit all needs.

NEW "JACKHAMER" DRILLS

THE Ingersoll-Rand Company has recently announced a new line of "Jackhamer" drills—the R-39, the S-49, and the X-59 weighing, respectively, 43, 57 and 72 pounds. These machines are essentially alike in construction, their size determining the class of work to which they should be put in order to get the best out of them.

The heaviest drill, the X-59, is designed primarily for deep-hole work—the blower style being used for open-cut and quarry operations and the wet style for underground work such as shaft-sinking. Because of its great power the X-59 is especially suitable for hard-rock drilling. The S-49, also a powerful machine, is intended for a wide range of excavating, road work, mining, quarrying, and shaft-sinking. The R-39 is particularly adaptable to light work in soft and medium-hard rock, for pop-holing, etc. The S-49 and the R-39 are furnished in three styles: the dry, for the ordinary class of work usually done by machines of this kind; the blower, where strong blowing is required to clean out cuttings; and the wet style, for mining and shaft-sinking.

Outstanding features of the new line of "Jackhamers", as listed by the manufacturer, are: Elimination of valve chest on side of cylinder; use of the Ingersoll-Rand "flapper" valve; throttle in the handle; bushed type of rotation sleeve; swivel air connection; and new type of steel holder that prevents wear on fronthead.

Rust and corrosion, say Sheffield experts, are responsible for a loss each year of 25 per cent of all the iron and steel made throughout the world. The value of the metal thus destroyed annually is computed by them at $2,500,000,000.

Meteor Crater Again a Scene of Activity

What Has Been and Is Being Done in an Effort to Reach the Deeply Buried Main Mass of the Meteor

PART II

By R. G. SKERRETT

CONVINCED that the crater is of meteoric origin, Mr. Barringer and his associate erroneously decided—because the crater is almost circular—that the meteoric mass had struck the desert nearly perpendicularly and was, therefore, buried somewhere beneath the center of the floor of the crater. That floor is virtually level; and at one time it was the bottom of a lake, as has been revealed by a considerable thickness of sediments which accumulated there when the basin contained water. In 1904, these men started to sink a shaft in the middle of the crater, intending to drive radial drifts therefrom when a solid formation should be reached—in this way hoping to get in touch with the deeply buried meteoric mass. After the shaft got down to 200 feet, quicksand, caused by a mixture of rock flour and water, was encountered. This effectually prevented further sinking of the shaft.

Balked in this manner, they then resorted to drilling deep holes in the general center of the crater to locate the meteoric mass which made the crater. To this end was sunk a total of 24 holes, ranging from a depth of 90 feet to over 1,000 feet below the level of the floor of the crater. While these did not encounter the sought for mass, they did bring to the surface numerous small pieces of oxidized meteoric iron, ground up, of course, by the revolving solid fish-tail bit. These pieces furnished additional evidence that the crater was of meteoric origin. The drill holes also established the facts that the crater was filled below its floor with 700 or 800 feet of rock fragments and powdered rock—the latter of extraordinary fineness, and that the underlying bed of red sandstone was undisturbed, that is, nowhere tilted from the horizontal as would be the case if it had been more deeply penetrated by the comet. With the exception of the uplifted section of the south rim, all the other disarranged strata dip away from the center of the crater. Deep drilling failed to disclose volcanic rock of any description. These revelations were made over a period of years that came to an end in 1908 when drilling in the center of the crater ceased because of lack of funds.

Strange as it may seem, then, and not until then, did the owners of the property interpret the evidence afforded by the rocky walls of the crater and logically analyze the manner in which the rock was tilted, well-nigh symmetrically, on each side of a line traversing the plan of the crater from WNW. to ESE. It is along this general line that the crater is slightly wider. Also on each side of this line lie fields of enormous fragments of limestone—the rock being uplifted as though it had been heaved outward by an inconceivably monstrous plow while burying its point deeper and deeper into the formations. This disposition of the rock indicated that the mighty projectile approached from the north at an angle, now supposed to be about 45° from the vertical. But before coming to rest above or in the top of the bed of hard red sandstone, the metallic head of the comet lifted for a vertical distance of about 100 feet a section of the southern wall of the crater—something like 2,700 feet in length from end to end, and caused that body of rock to be arched in a significant way. That upheaval, when correlated with other evidence tending to show that the comet had approached from a northerly direction, finally convinced Mr. Barringer that its deeply buried head lay somewhere beneath that great uplifted mass of rock strata. The next thing was to obtain needful funds to sink an exploratory drill hole deep enough to penetrate some part of the supposedly underlying meteorite.

With funds available, a churn drill was set up in 1920 on the southern rim of the crater. The position chosen was at the top of the arched section and near where the only fragments of the lowest, brownish-red portion of the saccharoidal white Coconino sandstone were found. This, evidently, was the last and lowest rock to be thrown over the rim of the crater. Incidentally, a much greater quantity of rock fragments was ejected southward than in any other direction. The churn-drill hole was sunk as close as possible to the center of the 2,700-foot section of uplifted rock, and penetrated the rock to a maximum depth of 1,376 feet.

Not until the drill had reached a depth of more than 1,100 feet were pieces of oxidized meteoric iron, carrying nickel, found in the shattered sandstone. Thereafter, with each added foot of penetration, was obtained more and more of this oxidized meteoric material identical to that forming the oxidized crust of the shale balls. Just before reaching 1,376 feet, the ground penetrated was composed of nearly 75 per cent of meteoric material, according to the rough estimate made by the driller. At that depth, the drill be-

On the present floor of the crater and close to the center of that great cavity. Here it was that efforts were first made to sink a shaft for the purpose of reaching the buried cometary body then mistakenly supposed to lie directly beneath that position.

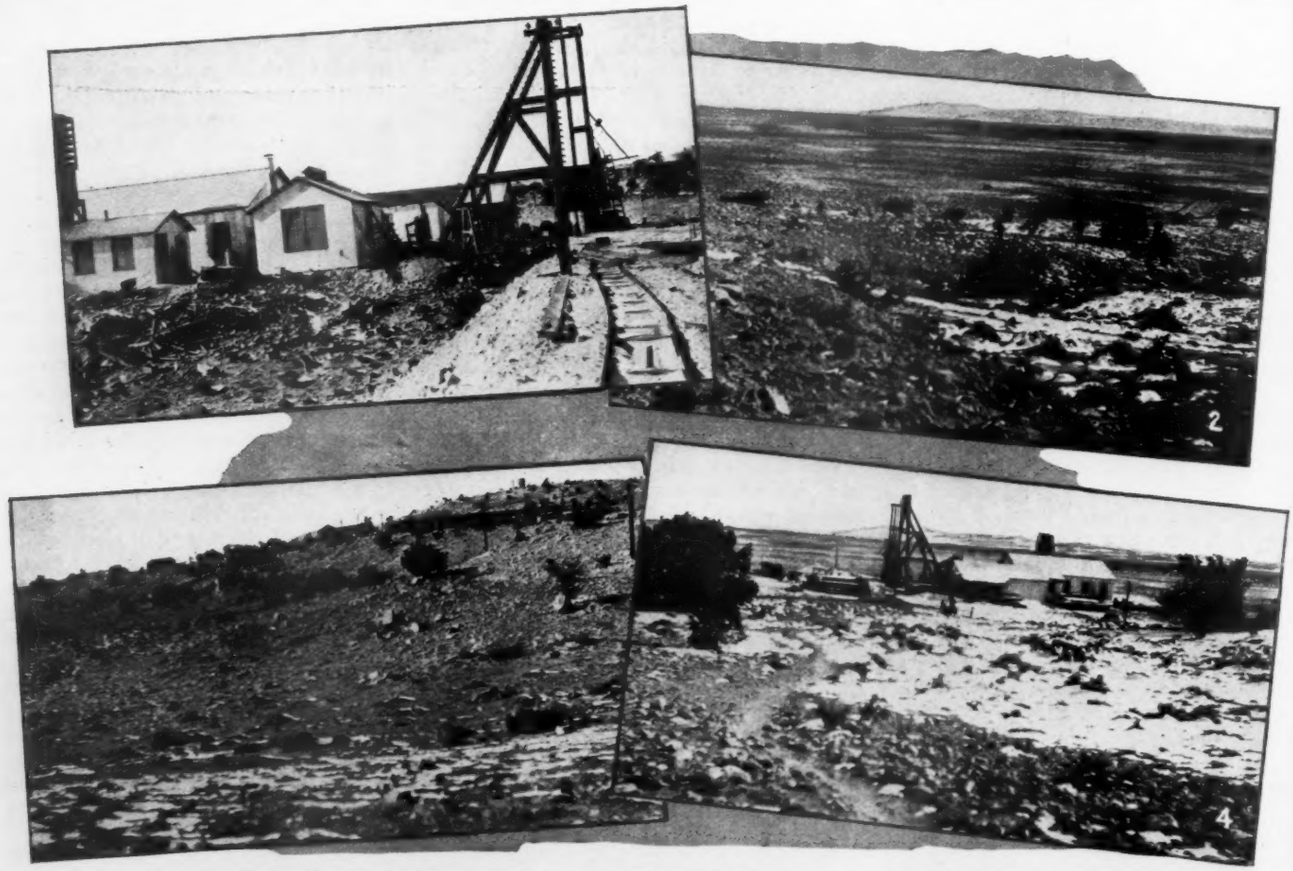
came irretrievably jammed, possibly between masses of meteoric iron. It is inferred that the drill had reached the top, or close to the top, of the great celestial iron mass which made the crater.

With the hole plugged at the bottom by the imprisoned drilling tool and the broken cable, further exploration could have been carried on only by sinking another hole, which would have been a matter involving a large expenditure of money. With the available funds then nearly exhausted, it was decided to abandon further work along that line; but the drill had proved convincingly that the great meteoric mass lay beneath the southern slope of the crater at a depth of more than 1,300 feet and vertically below the crater's rim. The next problem was to obtain additional resources and to plan a different method of approach to the buried meteoric mass of iron and nickel, which had been proved to carry considerable percentages of platinum and iridium. Before describing what was done to this end, let us see what the experts believe the size of the meteoric mass to be.

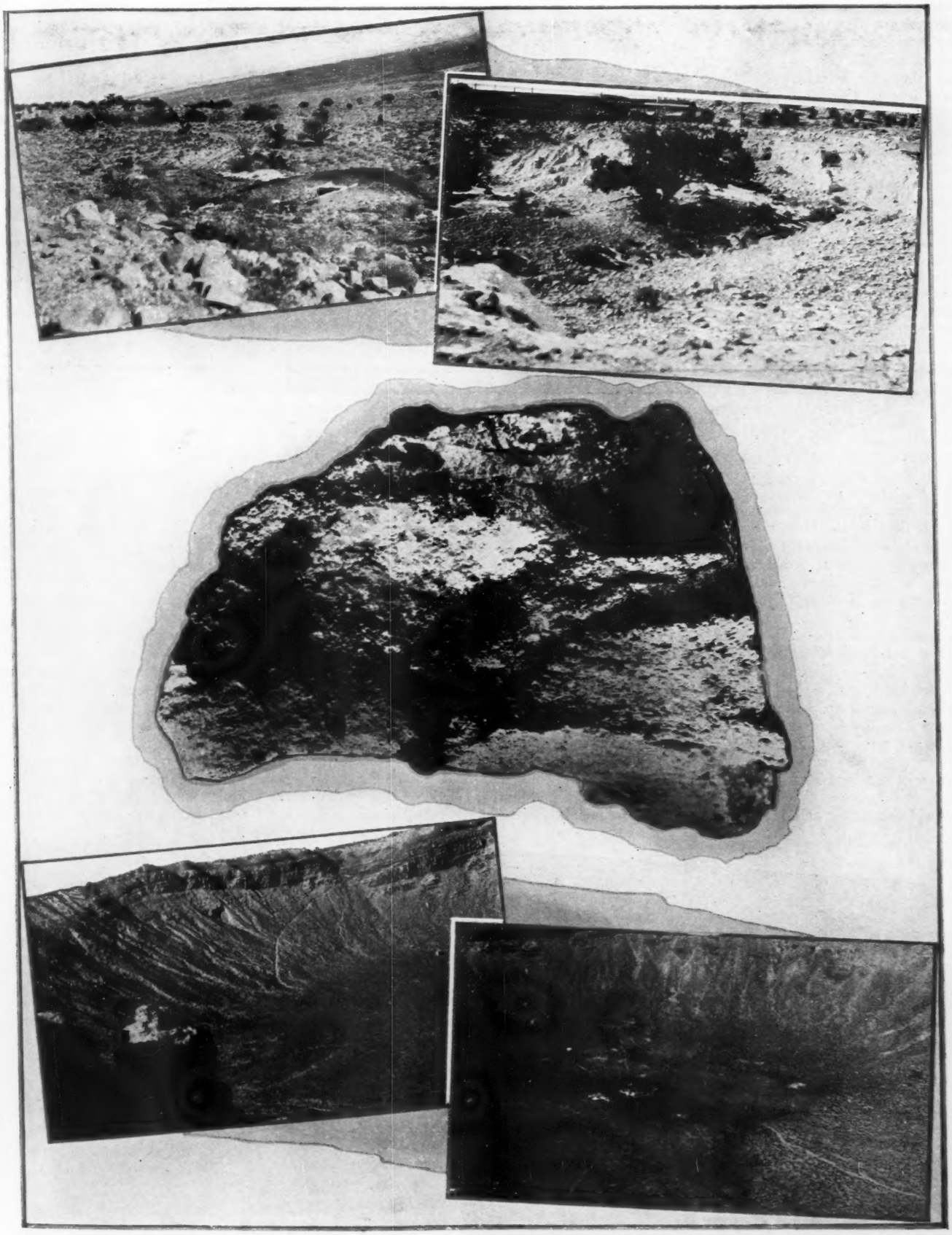
It should be recalled that an iron meteorite, said to be the largest body of its kind so far found, fell a short while ago in South-West Africa. Its dimensions are reported to be 10x10x4 feet, and its weight has been estimated at approximately 60-odd tons. That meteorite struck the earth with sufficient force to crush an exposed stratum of limestone and to excavate for itself a resting place ranging from 3 to 5 feet in depth. These figures are especially interesting because they indicate in a general way how many times larger must have been the mass that dug Meteor Crater in Arizona. The dimensions of Meteor Crater, as it exists today, are known; but the size of the projectile that made the crater still remains undetermined.

There are ballistic formulae—such as are commonly used in arriving at the penetrative powers of an armor-piercing shell—that can be employed in estimating the energy developed by the meteorite when it hit the rocky strata of the Arizona desert. In these formulae, the size, the weight, and the velocity of the projectile are known. In the case of the comet that dug Meteor Crater these factors are not known. However, Dr. Elihu Thomson, of the General Electric Company, Prof. William F. Magie, the head of the Department of Physics at Princeton University, and other distinguished physicists have made a number of calculations. They have assumed that the meteoric mass struck with a velocity of from two to four miles a second; and they have deduced from the work done, etc., that the comet's nucleus must have weighed about 10,000,000 tons. They feel sure that a mass of less than 400 feet in diameter could not have crushed and displaced approximately 400,000,000 tons of solid rock, nor have penetrated in its slanting course about 2,600 feet of this rock! Mr. Barringer was the first to point out that such a high-speed projectile—approaching the earth at an angle and keeping to its line of flight until it came to rest after penetrating deeply into a yielding rock strata—must, inevitably, have produced a nearly round crater, strange as that may seem. Many experiments with a high-power rifle have shown that the bullets will form similar holes when going deeply into a yielding target. This discovery is suggestive when seeking an explanation of the origin of the craters of the moon.

Many analyses and assays of the unoxidized or metallic meteoric material have shown an average content of 93.3 per cent of iron and 6.4 per cent of nickel—carbon, phosphorus, and minute quantities of sulphur, cobalt, copper, silicon, and chlorine constituting the remainder, with the important addition of about .4 of an ounce troy of platinum and iridium to a ton avoirdupois of meteoric iron. The oxidized material naturally shows somewhat lower metallic values, due, of course, to the addition of oxygen. Based on more than 50 analyses and assays of surface fragments, considered as a good cross-section sample of what the meteorite itself contains, each ton of recoverable material would carry, at present market prices, in excess of $50 worth of nickel,



1—Power plant and headframe at the shaft now being sunk about 1,000 feet to the south of Meteor Crater. 2—The desert, viewed from the south slope of the crater, dotted here and there with rocks that were hurled from the crater in the dim past. 3—Camp where the workers are housed who are now engaged in sinking the 1,500-foot shaft. 4—Another view of the power house and the headframe at the deep shaft.



Top, left—Snapshot from the southern slope of the crater looking eastward toward the surrounding desert. Right—Here and there at points on the outer slopes of the crater stunted cedars and other evergreens have obtained a shallow foothold. Center—A piece of altered sandstone that now closely resembles pumice and which is light enough to float. Bottom, left and right—Recent snapshots of the interior of Meteor Crater viewed from the site of the churn-drill hole sunk at the southern lip of the great basin.

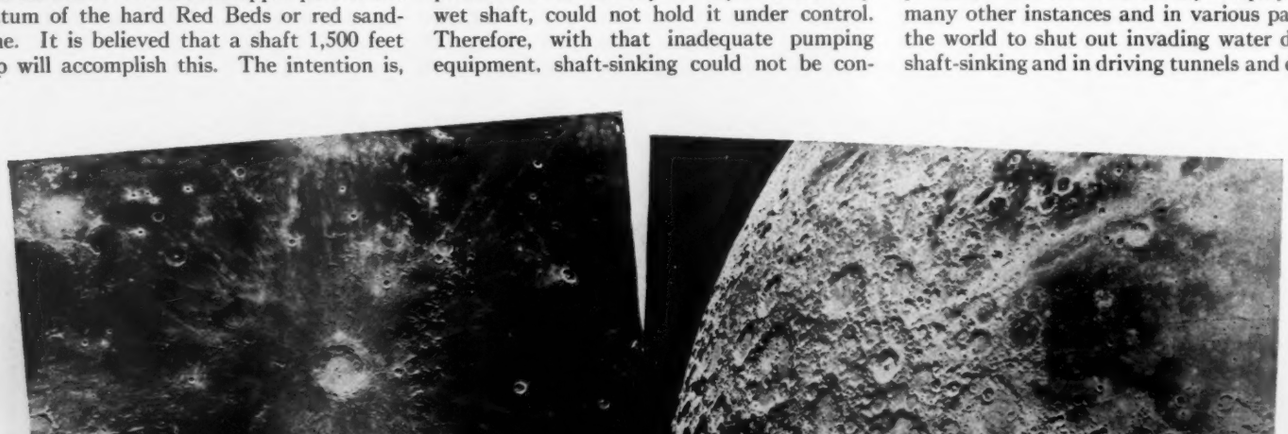
platinum, and iridium. One does not have to do much calculating to see how potentially rich is that buried meteoric mass if the foregoing scientific conclusions be anywhere near correct. From a metallurgical point of view, the meteoric material, whether metallic or oxidized—and most of it is probably in an oxidized condition, should present no difficulties in smelting. These facts are mentioned not for the purpose of giving a commercial color to the exploratory work, but merely to indicate that the deposit of celestial origin has practical potentialities aside from the great scientific interest attaching to it.

Section of the inner rim where the disposition of the shattered rock plainly indicates the violence of the forces at work there in the distant past.

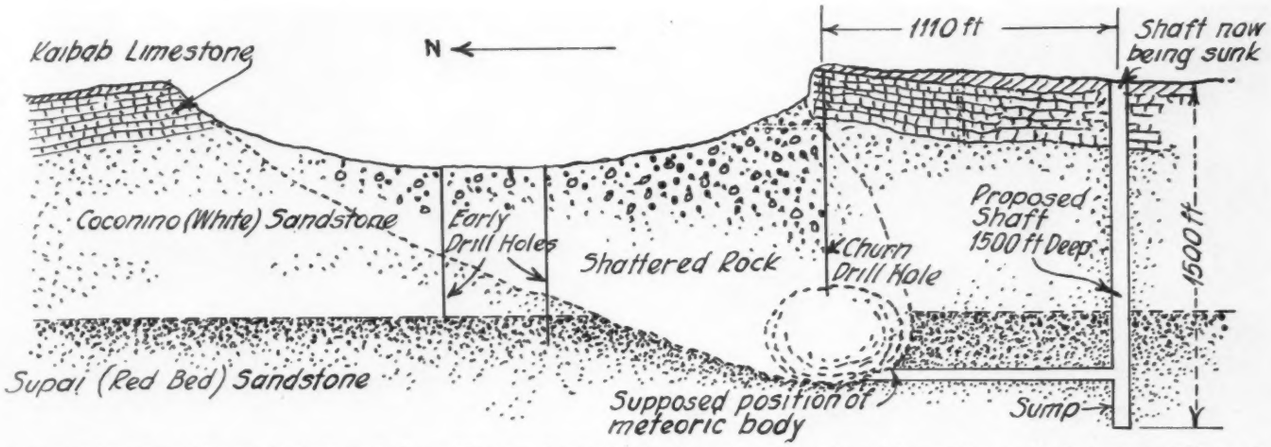
Now let us describe the third and present attempt to reach the head of the comet that dug Meteor Crater in the dim past. This work is being done by the Meteor Crater Exploration & Mining Company, of which Quincy A. Shaw of Boston is president, D. M. Barringer is vice-president, and G. M. Colvocoresses of Humboldt, Ariz., is general manager. In order to reach the meteoric mass and, at the same time, to avoid the expensive handicap of going through badly broken rock, the engineers of that organization decided to sink a shaft at a point 1,100 feet nearly due south of the churn-drill hole—far down on the outer slope of the crater—and to carry the shaft deep enough to penetrate for about 100 feet the upper part of the stratum of the hard Red Beds or red sandstone. It is believed that a shaft 1,500 feet deep will accomplish this. The intention is, when that depth is reached, to drive a drift northward from the bottom of the shaft directly toward the assumed position of the buried mass of the great bodies of the iron meteorites. This shaft, which has over-all dimensions of 7x12 feet, was started last autumn—air-driven rock drills being used in the operation. The shaft-sinking was in capable hands, and the work was carried on in three shifts in order to hasten the undertaking.

Everything went well until the shaft attained a depth of between 650 and 670 feet, and then the unexpected happened; water came in from the surrounding formation at an increasing rate. In fact, the inflow became such that the pumps, which had been provided on the theory of only a moderately wet shaft, could not hold it under control. Therefore, with that inadequate pumping equipment, shaft-sinking could not be continued. When it became evident that the subsurface area in and about this section of the crater held a large amount of water—even though in the heart of a desert region—and that this water had accumulated in all probability over a long period of time, work was temporarily halted. Consideration was then given to ways and means that promised success in getting through the water-bearing table—the thickness and even the existence of which could not be foretold.

After due study of the situation, a new plan of attack was devised, and an amplified plant is being assembled for the resumption of shaft-sinking. Broadly stated, the new procedure will involve the drilling of a number of high-angle holes from the bottom of the shaft into the surrounding area below, through which the shaft is to be deepened. Through these holes fluid concrete or grout will be forced under high pressure into the enveloping rock; and the grout is relied upon largely to seal off the water now coming from the rock, thus enabling the shaft to be sunk within the protected area. This method will be resorted to either intermittently or throughout the whole projected depth of the shaft, depending upon conditions encountered as the shaft is sunk deeper and deeper. This process, known as the François cementation process, has been successfully employed in many other instances and in various parts of the world to shut out invading water during shaft-sinking and in driving tunnels and drifts.



Left—Lunar crater Copernicus photographed from the Mount Wilson Observatory. This crater is about 50 miles in diameter. The radiating light streaks are assumed by some scientists to indicate the "splash" of pulverized rock produced when a tremendous celestial body collided with the moon. Right—This pock-marked area of the moon, showing hundreds of craters of different sizes, is said to be the mute reminder of remote collisions between the moon and wandering celestial bodies or aggregations of such bodies.



Cross section along the north and south line of Meteor Crater indicating the supposed position of the meteoric body and the rock strata through which it bored its way for a distance of more than 2,500 feet in penetrating to a depth of about 1,300 feet.

Leaving the preliminary mining operations where they now are, and wishing those behind the undertaking all possible success, let us consider in conclusion what Meteor Crater represents to the world at large as an outstanding scientific curiosity. Meteorites are of two great classes, those of iron and those of stone. There is an intermediate class composed of a mixture of iron and stone, but these are rather rare compared with the two others. We are dealing at Meteor Crater with those that were originally of the metallic-iron variety.

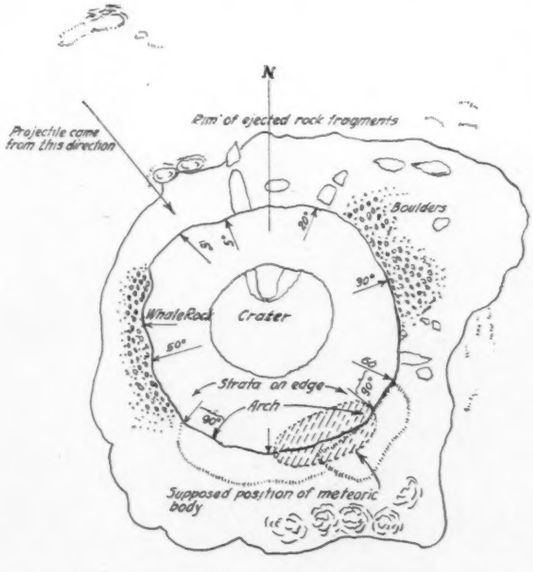
Even though meteorites of considerable magnitude seldom hit the earth, still some have done so within recorded history—a few of them in recent years. But so far as our knowledge goes, there is no evidence of the visitation of another celestial body in any way comparable with the meteoric mass that dug Meteor Crater, except the one which fell in Siberia in 1908. The erosive action of wind, rain, and frost during the ages has doubtless obliterated the evidence of many ancient collisions of a kindred nature, all of which tends to show the unusualness as well as the relative recentness—gaged by geological standards of time—of the great mass that made such an enduring impress upon the desert of Arizona.

The detection of minute diamonds in the meteoric bodies found in and around Meteor Crater has a fascinating significance. Diamonds are but a crystalline form of carbon, and carbon in both crystalline and graphitic forms has been found in all the Canyon Diablo meteorites. In many instances carbon is a transformed state of previous vegetation—changed by the action of great pressure and heat. Carbon has also been ascertained to be a component part of the sun. Well may we ask, "What, then, was the parent body from which these iron meteorites were derived, and in what condition was that body, possibly countless millions of years ago, before those meteorites were tripped in their course in outer space and turned earthward?" Surely the subject is one of amazing possibilities and offers a wide field for speculative thought.

Now what happened in Arizona may have occurred repeatedly in the dim past in the case of the moon. At least, such is the belief of some scientists. Mr. Barringer has presented a strong argument, published in the *Scientific American* five years ago, in support of the theory that all the craters on the surface of the moon are of impact origin and similar in many respects to the Arizona crater. The cavities that mar the visible face of that celestial sphere may easily have been produced by colliding masses of meteorites or solid matter. The mighty dents have remained distinct after eons of time because the moon has no atmosphere to provide wind and water to induce erosion, such as occurs with land surfaces on the earth. Because of its small gravitative force, the moon could not prevent the escape of hydrogen, if any of that gas were ever around that body. It is therefore probable that there never has been water on the moon. Since water is recognized to be the principal factor in volcanic action—steam being its chief propulsive force—there is warrant for the assumption that no volcanic manifestations have ever occurred on the moon. If that be true, then the moon's craters, like the one in Arizona, were caused by the impacts of bodies of solid matter that were gathered into the moon from outer space and without any retardation due to an atmosphere. Meteor Crater may thus add support to the planetesimal theory, advanced by Chamberlin and Moulton, which holds that the orbs that compose our solar system were built up, in part at least, by additions of solid matter from surrounding space—hitting, as evidenced in the case of the moon, with terrific force.

The silent testimony of Meteor Crater may be the means of clearing up the mystery of the so-called craters of the moon; and the amazing characteristics of the meteoric iron, fashioned in the unimaginable crucibles of the skies, may ultimately lead our metallurgists to discoveries of the greatest value. No wonder the Indians of the surrounding region have for untold centuries held Meteor Crater in awe.

To Daniel Moreau Barringer credit is undoubtedly due for having been the first to advance and to prove the meteoric origin of this remarkable formation in Arizona. He has told of his investigations and his conclusions in numerous scientific papers that he has written on this absorbing subject. What has been accomplished already has served to whet the curiosity of both the popular and the technical reader; and surely there is therefore every reason to wish the Meteor Crater Exploration & Mining Company success in its present quest.



Plan of Meteor Crater illustrating some of the outstanding features of this vast and spectacular hole in the heart of the Arizona Desert.

The jubilee gift of substantially $1,340,000, presented by Sweden to His Majesty King Gustaf V on his seventieth birthday, is to be used in a fight against cancer. It is the wish of the king that a new radium hospital be built in Stockholm, and that the sum given him be used in studying cancerous diseases and in combating them.

Ewing Galloway, New York

Looking north from Battery Park, New York City, into the spectacular architectural canyon of lower Broadway. The massive buildings rest upon firm foundations built with the help of compressed air and pneumatic rock drills.

Cat Canyon Unique in California Oil Fields

Gas Lift Shows Substantial Profits Where Operation Entailed Heavy Losses Under Mechanical Pumping

By S. G. ROBERTS

WHY Cat Canyon is so named is not a matter of historical record; but the designation may have originated in the days when either wild cats or mountain lions prowled numerously about that part of Santa Barbara County, California. Cat Canyon is of economic interest today because it is a fine example of an oil field that now shows a substantial profit where for years the figures were invariably "in the red". Cat Canyon's present prosperity is cumulative evidence of what patience and modern engineering practice can accomplish in the face of discouraging records covering a period of something like a decade and a half.

As an oil field, Cat Canyon is unique—unique because of the nature of its product; but before taking up this phase of the subject let us locate the canyon so that our readers will have no trouble in finding it upon the map. Cat Canyon lies in the foothills of the San Rafael Mountains, about 17 miles in from the coast and 75 miles north and west of Santa Barbara. Scenically, the situation is a fine one; but from the angle of accessibility the neighborhood leaves something to be desired. The roads to it, however, are for the most part excellent, and a run there in a good motor car is a treat.

Oil was struck in Cat Canyon between fifteen and seventeen years ago; and the oil was found to differ notably from the petroleum produced elsewhere in California. The oil is really a slightly modified straight asphalt, totally devoid of any lubricating factor, and yielding, when treated, about 18 per cent of gasoline. The contained gasoline is virtually a godsend, because it is this constituent that lessens the viscosity of the petroleum and helps to make it possible to recover the stuff from the bowels of the earth. The oil has an index of 10, according to the Baumé scale, and is heavy enough to sink in water. At the start, the oil not infrequently holds in suspension as much as 78 per cent, in volume, of sand; but this gradually decreases, and the average working well will show an output of only from 3 to 6 per cent of sand.

Up to 1925, there were but ten wells producing in the field, and those, as we have already mentioned, operated at a loss. The best any of them could do prior to 1925 was to yield 75 barrels a day per well; and each well could then run on an average of not more than eighteen days a month—the rest of the time being given over to correcting pump, rod, and tubing troubles. Sand was the main cause of the production difficulties. The situation seemed a hopeless one until steps were taken about four years ago to substitute the

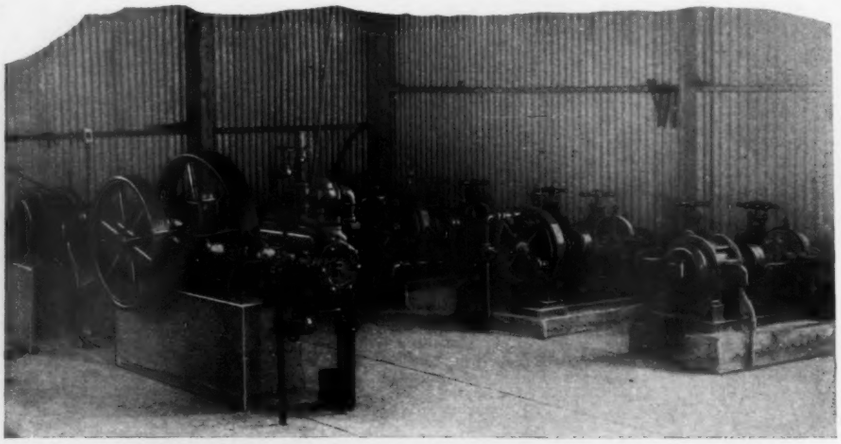
Left—Sump with tributary trenches that convey the oil from a group of wells.

Right—The viscous oil has the consistency of partly pulled taffy.

Bottom—Another view of an oil sump and the open trenches by which the petroleum flows from neighboring wells.

gas lift for the previously employed mechanical pumping systems.

This innovation was made in May of 1925, when Grover Moore went from Signal Hill to Cat Canyon for the special purpose of determining how far the use of the gas lift would be able to improve production in the canyon. The first well put on gas in that field was the Riverside & Gilmore No. 4—generally known as the R & G No. 4. The well was put on gas on June 7, and production instantly jumped from the previous 75 barrels a day to 580 barrels every 24 hours! Up to December 7, 1928, when the property was visited by the writer, the well had been off production not more than ten days in more than three years; and its output then averaged 150 barrels *per diem*—twice that previously possible with mechanical pumping.



A battery of Cameron pumps, in a Cat Canyon compressor house, providing circulating water for various purposes.

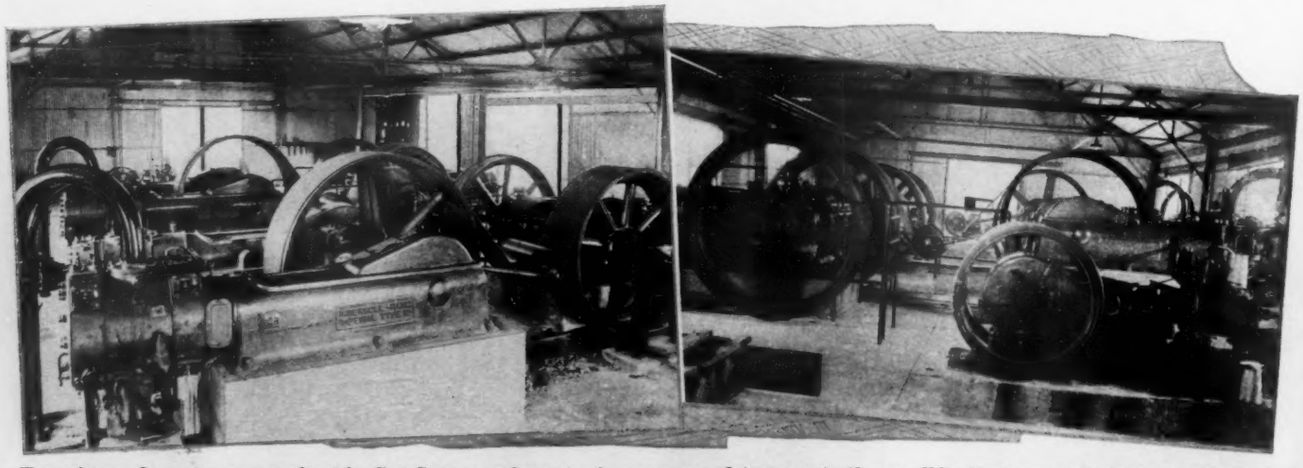
The success attending Mr. Moore's adaptation of the well-known air lift—substituting natural gas for air—has been the outcome of ripe experience plus much patient experimenting in order to meet the conditions peculiar to the Cat Canyon field. Without going into details, it may be stated that he found it highly desirable to employ a considerably larger eduction pipe than had been customary when using the gas- or air-lift method of pumping oil of much lower viscosity and lighter weight. In addition to that, he also discovered that much better results could be obtained when the lifting gas was heated—the warm or hot gas serving to reduce the viscosity of the oil and greatly to facilitate raising it to the surface of the ground. For example, when the gas is not heated the operating pressure will jump 50 pounds, and production will fall off quite 50 per cent within two hours after ceasing to heat the gas. The gas is heated by steam before it enters the casing head of the well, where the temperature ranges between 170 and 200° F.

While the underlying principles of the air or gas lift are generally well known, still it may not be out of place here to describe in a general way the manner in which the gas lift functions in the Cat Canyon oil field. The producing sands have a vertical thickness of approximately 300 feet, and the wells are drilled to a depth of 3,500 feet. The rock pressure is great enough to raise the oil 3,000 feet in the hole. The practice is to use an 8¼-inch casing, and to insert within that casing a 6-inch induction tube through which the oil reaches the surface when the gas lift is operating. The casing is headed in at the top, and the eduction pipe passes through this seal. At a point 3,100 feet down from the surface—that is, 100 feet above the top of the production zone—a perforated footpiece or "mixer" is fitted to the eduction pipe. Now when the fluid enveloping the eduction pipe has been forced down by gas pressure to the level of the "mixer", then the compressed gas and the oil are forced through the perforations and, because of the wire-drawing action so induced, are commingled—forming a fluid body having about 45 per cent the weight, per unit of volume, of the normal petroleum in the well. As a consequence, the heavy column, acting against the lighter column, forces the gas-oil mixture surfaceward.

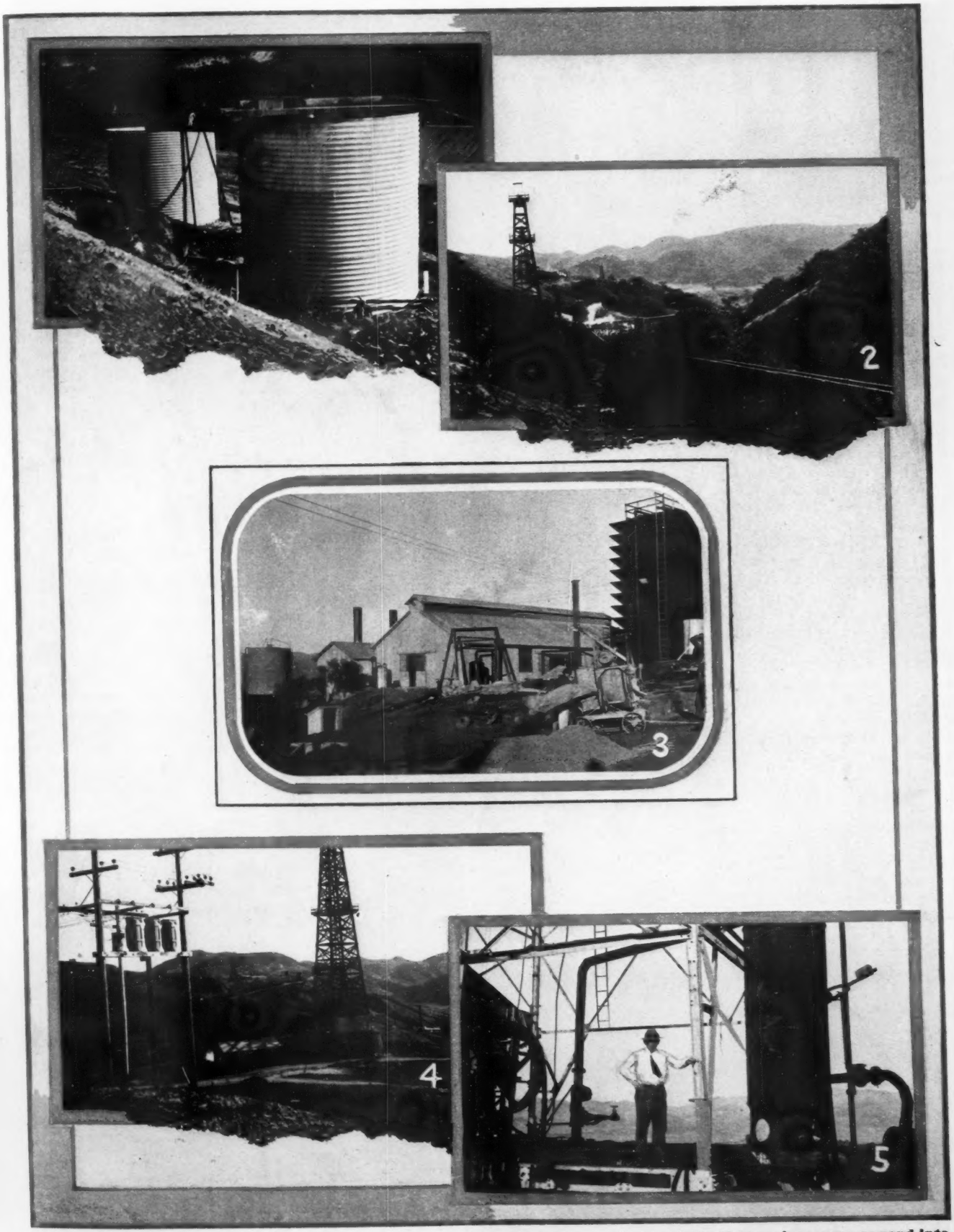
The gas pressure for starting a well is around 1,000 pounds per square inch; and the working pressure of the pumping gas also varies with the wells. For instance, the working pressure on one well runs between 320 and 480 pounds, while for another well the pumping pressure is as high as 840 pounds to the square inch. The gas-oil ratio averages 700 cubic feet of gas for each barrel of oil produced—that ratio including both the gas from the formation and the gas supplied by the compressors. After reaching the surface, the oil flows through a gas separator; and the gas is recycled and goes back to the compressor plant for re-use in the wells.

When the wells in Cat Canyon were pumping on the rod, each well produced about 50,000 cubic feet of gas daily. By utilizing the gas lift, each well averages something like 150,000 cubic feet of gas every 24 hours; and this gas serves the twofold purpose of recovering the oil and furnishing fuel for raising steam that is used to operate well drills, to heat input gas, and to run some of the pumps and compressors.

The practice is to raise the pressure of the operating gas through three stages of compression. The gas from the separator has a pressure of 5 pounds to the square inch, and that gas is fed to the low-pressure machines and there brought up to 80 pounds. In the second stage, the gas is raised to a pressure of 400 pounds; and in the final stage, the pressure is raised to 850 pounds. A typical up-to-date plant in the field—one furnishing gas for pumping seven wells—contains the following units: three 2-stage Imperial compressors driven by 165-hp. Bessemer gas engines; and two steam-driven boosters—one an XPV and



Two views of a compressor plant in Cat Canyon where gas is compressed to operate the gas lifts that pump the extremely viscous petroleum obtained in that field.



1—Water tanks that are filled by air lifts operating in abandoned oil wells. 2—In the middle distance is a sump or pond into which the oil flows by way of open trenches. 3—Compressor plant that furnishes operating gas for a number of oil wells. 4—A typical section of the Cat Canyon field. 5—Close-up of a well pumped by means of gas lift.

Left—Plant furnishing steam for pumping and for heating the gas used in raising the oil to the surface. Center—Mr. Grover Moore who has adapted the gas lift so successfully for pumping viscous oil. Right—Some of the profitable wells in the Cat Canyon field.

the other an FR-1 compressor, both Ingersoll-Rand machines.

Such a station usually has a number of pumps for handling circulating water; and a closed system is employed inasmuch as the water is rather bad because of the solids in suspension. For example, one pump will put the water through the closed system, while a second pump will take the water from a settling tank and distribute it over the cooling towers. The pumping plant is made up of four Cameron No. 3 NFV units—two turbine and two motor driven. Only two pumps are required for service at any one time. An ER-1 compressor is also provided to furnish starting air and air for other purposes around the plant. The steam used is furnished by two 300-hp. Babcock & Wilcox boilers, at present fired with oil and a small quantity of distillate. The oil is one of the very finest fuel oils in the state because of its high B.T.U's. It is likely that gas will be employed later under the boilers because of the greater market value of the oil.

Now let us follow the oil after it leaves the separator. Some idea of its viscosity can be gathered from the fact that in making a vertical drop from the discharge pipe the oil falls sluggishly, like taffy when partly pulled, and moves with the traditional speed of cold molasses when flowing down a trench in a hillside that has a slope of 25°. At some of the properties in Cat Canyon, the oil, as it comes from the wells, flows by gravity to basins or sumps where it is heated with steam coils to make it more fluid and to promote the precipitation of the contained sand. This procedure entails a considerable cost in fuel and also facilitates the escape of much gas that carries gasoline.

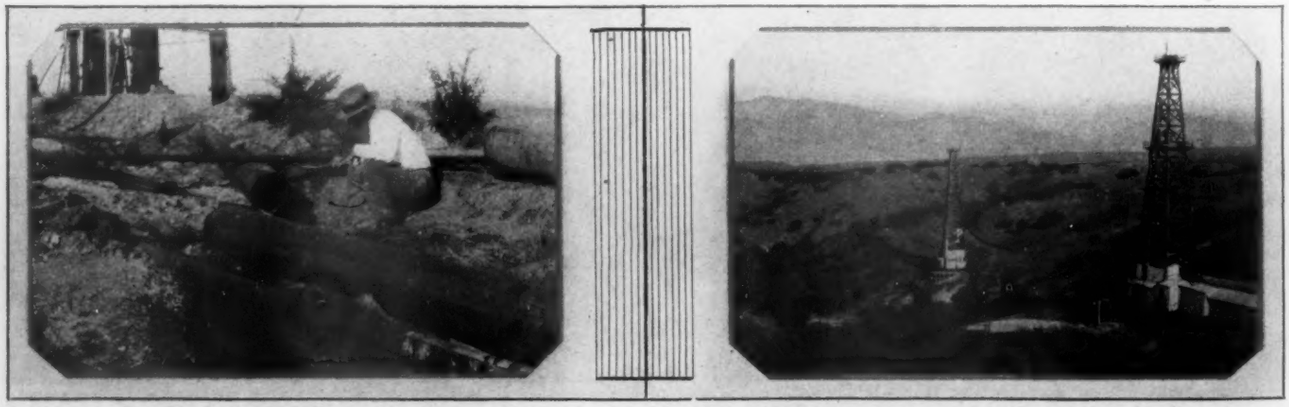
The better practice consists of adding 15 per cent of distillate to the oil after it has been put through the gas separator immediately upon issuing from a well. This additional distillate reduces the viscosity and adds greatly to the ease with which the oil can be handled. Incidentally, it promotes the rapidity with which the oil can be counted upon to purge itself of sand while passing through a sand trap in a closed circuit. At the same time, none of the wet gas escapes; and all the gasoline can be recovered from the oil.

The pumping gas is transmitted through a high-pressure line that traverses each lease, and laterals lead off from this line to the individual wells, with control valves at each well. The system makes it practicable to pump simultaneously from six wells just as economically as from two wells. That is to say, the additional four wells cost only one-third more to operate than the two wells—the overhead for all six remaining constant. In brief, what has been done in the Cat Canyon oil field since the first half of 1925 has made a paying proposition out of properties that previously were worked only at a loss. There are now 25 producing wells in the field.

Someone will probably ask, "To what use could oil containing so high a per cent of asphalt be put?" And the answer is that that particular oil is distinctly superior for road-surfacing purposes. At Cat Canyon the oil is sold, untreated, for 65 cents a barrel. When treated—that is, after the removal of the gasoline—it brings as much as $1.60 a barrel in small quantities, and in large quantities it is marketed at $1.10 a barrel. Even at 65 cents a barrel, because of the low cost of production by means of the gas lift, the oil nets the operator a very handsome return.

Much water is used, of course, in the field, and most of the supply is obtained from old oil wells that have been plugged below the water-bearing stratum and the casings of which have been perforated where they pass through the ground water area. The water is brought to the surface by means of air lifts; and there are five air-lift pumping stations in the canyon. The water is lifted commonly a matter of 500 feet.

Approximately 34,000,000 tons of scrap iron and steel, valued at more than $50,000,000, is used annually by the steel mills, blast furnaces, and iron foundries of the United States.



Left—The viscous oil flowing sluggishly down a trench in the hillside. Right—Cat Canyon field is picturesquely situated in hilly country.

Compressed Air Protects Power Plant From Hampering Ice

By SIDNEY MORNINGTON

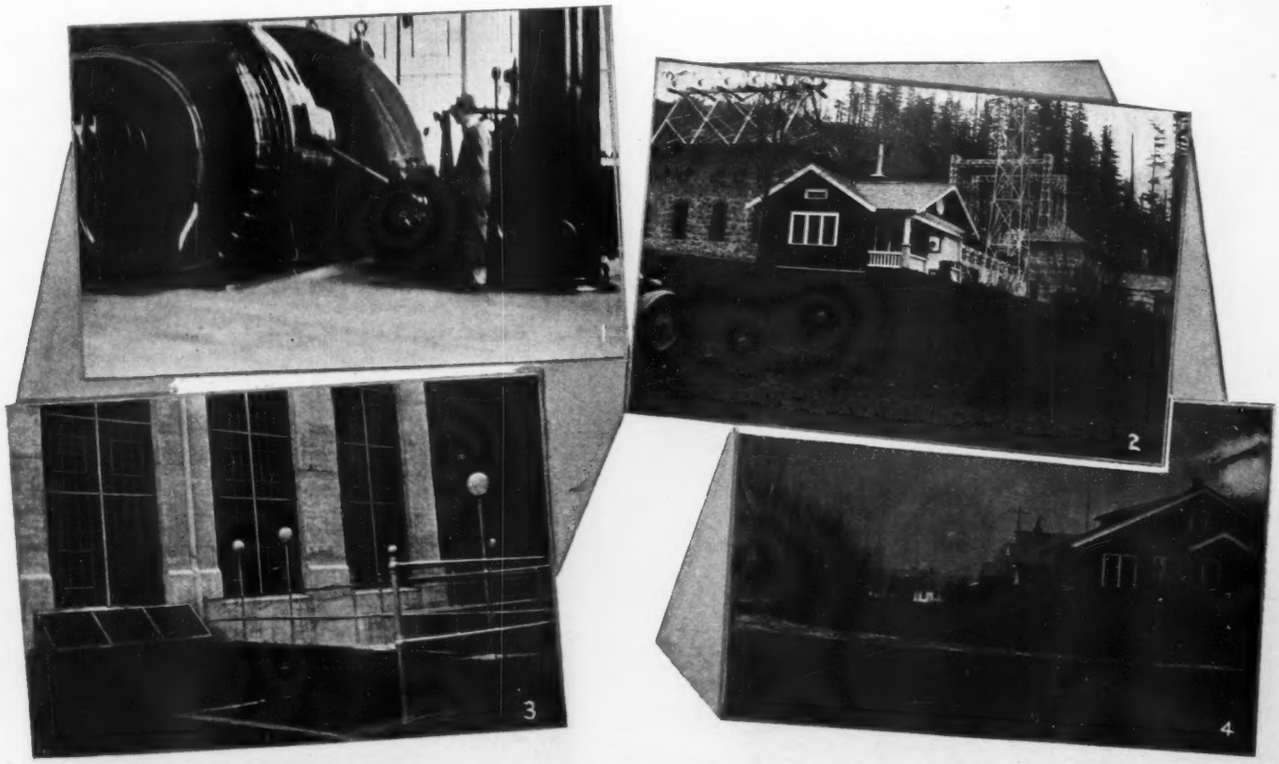
SEATTLE, Wash., is an up-and-doing city in many ways; and her people point with considerable pride to the several hydro-electric plants, operated by the municipality, that make it possible for the citizenry to enjoy current at exceptionally low rates for power and lighting purposes.

In owning and operating electric power stations, Seattle differs from most of the large cities of the United States. To this policy she has held for a considerable while, and even now she has obligated millions of dollars for the construction of still other large hydro-electric undertakings. Seattle is not disposed to hide her light under the proverbial bushel, if one can judge by the generous measure of illumination in evidence along her thoroughfares. She boasts 33 miles of streets made bright with cluster lights; and her electrically illumined thoroughfares aggregate 1,075 miles. Seattle has a population of 452,000; and most of these residents benefit by the municipal power system because the City Lighting Department carries 93,000 individual accounts for electric current—the assumption being that five persons on an average use the current covered by each account.

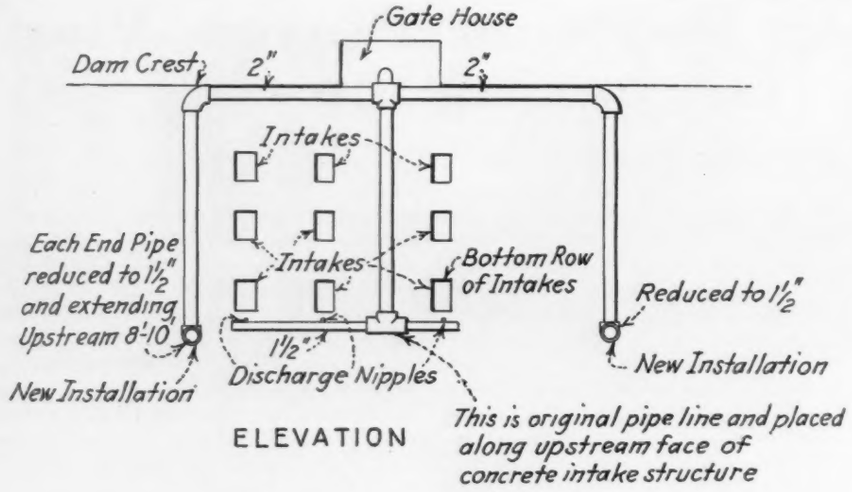
The foregoing particulars are merely by way of prelude to a description of an interesting installation made at one of the city's hydro-electric plants to safeguard that station from the hampering effects of ice during the winter and from fine trash at all times. We have in mind what is known as Plant No. 1, or the Cedar Falls unit of the City of Seattle, situated about 40 miles to the south and east of the municipality. That hydro-electric station is operated by water drawn from Cedar Lake, which, in its turn, obtains its supply from a watershed having an expanse of 80 square miles. The turbines that drive the generators in the power house work under a static head of 608 feet when the water is at Elevation 1,550—the five units now in service having a combined rated output of 25,000 kw. The municipality is adding a sixth unit of 12,500 kw. Manifestly, it is a matter of prime importance to the city and to the users that nothing should interfere with the operation of this plant.

The water of Cedar Lake is impounded by two dams—a crib dam 7,920 feet upstream from the main dam, which is of reinforced concrete. The concrete dam, which blocks the valley on a nearly north and south line, rests on solid rock; and the structure is 1,080 feet long and 215 feet high. This dam is provided with gate openings at levels 17 feet apart; and the lowest of the openings are at Elevation 1,500 feet. All the openings connect with a tunnel 11 feet in diameter—the tunnel being 10 feet below the lowest line of gates or intakes. This tunnel is linked by four penstocks that carry the water to the power house farther down the valley. These penstocks are constructed partly of wood stave and partly of steel. For instance, penstocks Nos. 1 and 2 are made up of 8,000 feet of wood-stave pipe and 1,000 feet of steel pipe. Penstock No. 3 is composed of about 5,300 feet of wood-stave pipe and 2,200 feet of steel pipe. Penstock No. 4 consists of substantially 2,400 feet of wood-stave pipe and 4,600 feet of steel pipe. The differences in the total lengths of the various penstocks are due to the different routes followed by them and to the contours of those routes.

There are gates and intakes above the crib dam, and these admit water to two pipes—one being 48 inches in internal diameter and the other 68 inches inside diameter. These pipes are formed of wood staves, completely enveloped by reinforcing concrete 6 inches thick; and they come together at a point about 35 feet upstream from the main dam, where they join a steel-plate elbow 15 feet long. From this elbow the water is carried to the tunnel in the concrete dam by a wood-stave pipe 78 inches inside diameter and 20 feet long. The object of providing two pipes



1—One of the generators in the power house at Cedar Falls. 2—Switchyard adjacent to the power house. 3—Glimpse of exterior of Cedar Falls power station. 4—Homes of operating personnel at Cedar Falls.



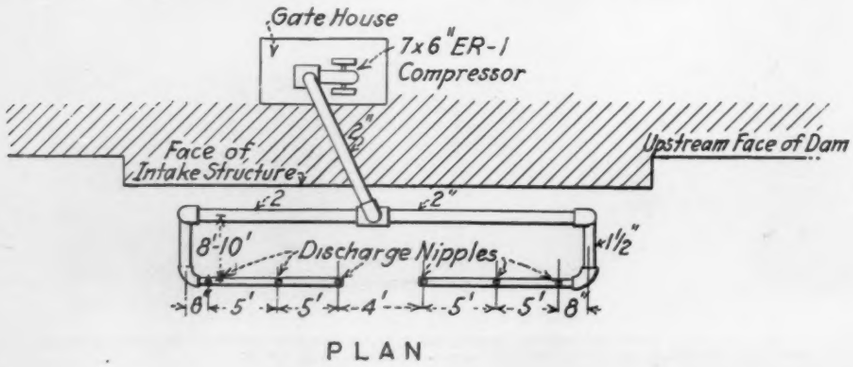
of differing sizes between the crib dam and the steel-plate elbow was to take care of varying power requirements at the hydro-electric station. The crib dam and the piping just mentioned make it possible to unwater the pond between the crib dam and the concrete dam so that the latter structure can be examined and cleaned from time to time without interrupting the flow of water to the turbines in the power house.

In December of 1924, slush ice accumulated under the surface ice that had formed in the basin or forebay between the two dams. This slush ice extended from the surface ice all the way down to the lowest gate opening, 85 feet below the water level. The slush ice obstructed the intakes; and as the column of water dropped in the connections between the dam and the power house—a matter of 600 feet—a vacuum was created that was sufficient to cause the deformation of the steel-plate elbow and the collapse of the wood-stave pipes when that line was opened so as to feed water to the turbines. Some of these heavy staves were swept into the tunnel and carried thence down to the machines in the power house. The situation was a critical one and called for prompt and heroic action.

The first thing necessary was to place a screen across the upper end of the open elbow where the stave pipes had collapsed, and this work had to be done by divers Two of them were employed for this purpose; and they labored in 85 feet of water that was filled with slush ice—the temperature of that ice being below the freezing point. These operations were carried on under the direction of J. L. McCartney, foreman of headworks, who noticed that the rising air exhausted from the divers' helmets melted the surface ice and kept a circular area clear. Mr. McCartney asked himself: "If released compressed air would do that in one case why would it not serve to keep the gate openings free of ice?" He realized that his question could best be answered by putting the theory to a practical test. Inquiry, however, convinced him that such a scheme would function effectively—the same principle having been applied to advantage in the case of a great dam on the Mississippi.

The quickest way to get compressed air at the dam was to buy a 7x6-inch Type 20 portable compressor capable of furnishing 170 cubic feet of air per minute. This machine was subsequently augmented by a stationary ER-1 compressor driven by a small 15-hp. oil engine. This unit provides air at a pressure of 95 pounds per square inch.

The three gates at each level are in line with the other row of gates directly above or below them. Accordingly, compressed air released from a point just below any one of the bottom gates will rise and sweep past the openings of the gates above as the air works its way surfaceward. With this in mind, the installation devised by Mr. McCartney was arranged to deliver compressed air to the operating points through a 2-inch pipe—that size being chosen in order to cut down transmission friction. At the lower end of this vertical pipe a tee was secured to which were connected two horizontal lengths of 1-inch pipe having discharge outlets immediately below the center of each vertical line of gates. These outlets were fitted with check valves to prevent flooding the piping when the air was turned off.



At first, ¼-inch openings were tried, but they discharged larger volumes of air than seemed necessary. Next, ⅛-inch nipples were used, and these proved large enough to insure an effective volume of air without overtaxing the capacity of the compressors. The compressed air was delivered directly from the machines to the 2-inch line instead of going first to a receiver.

By the time the compressors were available and Mr. McCartney had completed his tests, the season had moderated and no more trouble was experienced through accumulations of slush ice. Not until the winter of 1927-28 was it necessary to put the pneumatic ice defense to use. On one occasion during that cold season ice about 4 inches thick formed just above the dam, and the compressed-air apparatus was utilized to thaw that ice. The air was released during a single night, and it was able to thaw the ice for a radius of about 10 feet in front of each intake and thus to keep them all clear. At another time the apparatus was employed to deal with an accumulation of slush ice, and it worked with entire satisfaction.

Finally, during the winter of 1928-29, which was a rather severe one in that section of the United States, ice formed above the dam to a thickness of about 10 inches. Even so, Mr. McCartney was able to keep the intakes clear by means of his pneumatic protective installation—all the air necessary being furnished by his 7x6-inch ER-1 compressor. It should be mentioned here that the equipment has been somewhat amplified since first developed; and our sketches show the piping and fittings of both the original and the present outfits. Both of them are apparently now operated as a single unit.

Before the compressed-air defense was devised, the gate openings at all three intake levels were covered with 1-inch mesh screens. Latterly, these screens have been supplemented by a single boxlike screen that envelopes all the openings. This screen, which is generally rectangular in form and supported by suitable framing, extends 3 feet upstream from the dam structure. Thus a double line of defense is provided, and the arrangement serves effectually to arrest even fine trash which may be carried by the water at certain times. These various protective mediums have amply justified themselves.

Some of the conditions encountered at the Cedar Falls Dam are not unlike those occasionally occurring at many other power dams; and Mr. McCartney's way of overcoming troublesome ice may be suggestive to managements confronted with a kindred problem.

Detroit's industries are employing 75,000 more workers today than a year ago.

1—Upstream face of the Cedar Falls reinforced-concrete dam. 2—Upstream crib dam at Cedar Falls. 3—Section of the forebay or pond lying between the two dams. 4—Concrete span over which penstocks are carried across the valley below the main dam. 5—Gate house on main dam. 6—Downstream face of the large dam. 7—Enveloping screen and pneumatic ice defense at intakes on the main dam.

Autoists should appreciate the work performed by this pneumatic surfacer which removes, in short order, any rough spots or irregularities remaining on concrete roads after their completion or repair. This particular machine is the product of the Ingersoll-Rand Company, and is smoothing down ridges at joints in a New York State highway. Air to operate the surfacer is being supplied by the portable compressor at the left.

HYDRO-ELECTRIC POWER FOR PALESTINE

THE three small Diesel-electric power plants that are now supplying Palestine with a little less than 2,000 hp. of electrical energy are to be retired upon the completion at the end of this year of the great hydro-electric station now in course of construction below Lake Tiberias—better known as the Sea of Galilee, on the Jordan River. Between the site of this plant and Lake Tiberias, a stretch of about ten miles, the Jordan has a drop of approximately 150 feet, and this head is to be utilized in driving two vertical-shaft turbo-generators each capable of developing 8,000 hp. A third 8,000-hp. unit will constitute a spare. The current so developed will be carried at 66,000 volts over two transmission lines to Haifa and Jaffa, Palestine's leading Mediterranean ports. This plant is but one part of a great water-power project—the Rutenberg scheme—which has for its ultimate object the harnessing of the Yarmuk and of the Jordan, the latter from its source to the point where it empties into the Dead Sea.

From 1925 to 1927 the total rated capacity of prime movers in use and available for use in manufacturing establishments throughout the United States and driven by purchased current, jumped from 35,766,944 hp. to 39,040,563 hp., an increase in two years of 9.2 per cent.

"FLOP" FOR WAYFARING MINERS

"BACON'S 2 Bit Flop"! Here's local color for you, even though they say there is no romance left in the "North Country" because the coming of the airplane, the tractor, and the snowmobile, not to mention the modern hotel, have taken all the glamor out of frontier life.

"Bacon's 2 Bit Flop" stands but a stone's throw removed from the main business street of The Pas, situated not far from the rich copper districts of Flin Flon and Schist Lake in Northern Manitoba. The "flop" is raised several feet above the ground to save it from destruction by the spring floods that sweep through that section when the snows are melting rapidly.

The structure is rickety: it is no Chateau Laurier; but inside, says the *Manitoba Miner*, it is as spick and span a bunk-house as one will find in the best of mining camps. The proprietor of this picturesque "hotel" is Louis Bacon who, despite his 60-odd years, is also an ardent fisherman.

Comfort at low cost for miners is provided in this "North Country" bunk-house.

NEW RUST PREVENTATIVES

UNDER the names of "Paralan" and "Rustop", the American Lanolin Corporation, Lawrence, Mass., has put on the market two new materials for the protection of sheet and strip steel against rust. Both produce the same results, although differing in methods of application.

According to the manufacturer, "Paralan" is the outcome of efforts made to prevent rust from attacking the finished product of a large cold-rolled strip-steel plant. "Rustop", which dries quicker and leaves a bright film, provides a coating that will prevent oxidation and corrosion for a long period. It takes the place of the slushing oils and greases now commonly spread upon sheet or strip steel to protect it from rust during shipment. When dry, the films are said to be highly impervious to air and moisture; and as they are neither sticky nor greasy are easily removed by the use of hot water.

Promising deposits of cobalt are said to have been discovered in the Eastern Transvaal.

Refrigerator Car Works Wonders For Our Bodily Good

Some Facts About the Important Service Which Refrigerator Cars Render and How They Are Built

By A. S. TAYLOR

AMERICA'S amazing dietary! This is not a mere figure of speech—it is an established fact that is amply reflected in the general physical well-being of the dwellers within her gates. This fortunate state of affairs is primarily due to Nature's bounty and, next, to man's industry in utilizing or cultivating the resources thus made available. But even so, our tables would not be so generously supplied if engineering ingenuity had not devised ways and mean for the rapid transporting of these good and whol.some things from end to end of the country.

Because of the wide range in climatic conditions east and west, north and south, at given periods of the year, it is possible to have co respondingly diversified crops from the fields and orchards of the nation as a whole. Similarly, our rivers, our lakes, and areas of our coastal waters provide us plentifully at differing times with the best of their aquatic foodstuffs. As a general thing, all these comestibles, from either land or water, are of a perishable nature; and the zones of their distribution would be decidedly restricted but for the service performed by the refrigerator car. In a sense, so far as our food supplies are concerned, the refrigerator car offsets or neutralizes climatic differences—amplifying locally available edibles to an astonishing degree the year round to tickle our palates and to provide for our healthful sustenance.

There has long been a willingness on the part of a considerable percentage of the consuming public to pay a goodly price for fruits and vegetables locally out of season. This attitude explains in a measure how the refrigerator car came into being and then was developed and adapted for the general transportation of perishable foodstuffs. This business is still in an evolutional stage despite its present magnitude; and the desire on the part of the shippers as well as the distributing railroads is to deliver these commodities to the ultimate purchaser in a condition that will approximate closer, in the cases of numerous foodstuffs, that freshness and palatableness that is characteristic of similar commodities grown nearby and quickly marketed. Much, indeed very much, has already been

1—Forging center plates with a drop hammer in the well-equipped blacksmith shop of the plant. 2—This air-operated machine rivets the center sills of the steel underframes. 3—In this shop the trucks are assembled ready to be placed under refrigerator cars. 4—Reaming an array of drop-forged center plates.

Left—Here we see how some of the fabricated lumber is used in framing a refrigerator car. Right—Assembling one of the two ice tanks with which each refrigerator car is equipped.

achieved to this end.

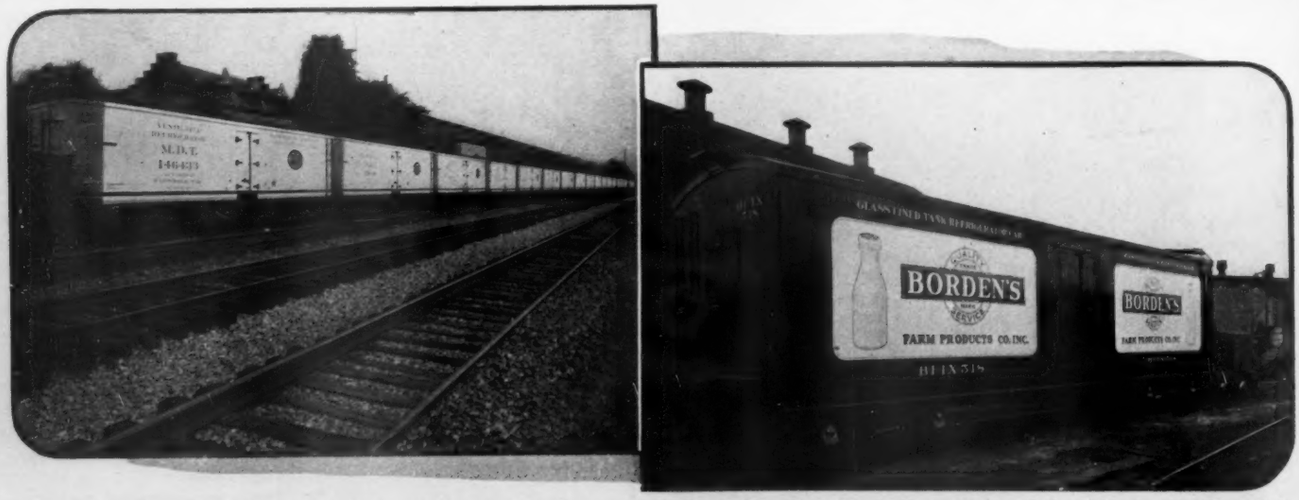
According to Eugene McPike, manager of the Perishable Freight Service of the Illinois Central System, the first experiments with refrigerated transport were made on the Illinois Central, and as far back as 1868. Then, one Parker Earle, of Cobden, Ill., shipped fresh strawberries under refrigeration. Special refrigerator boxes were constructed for the purpose, and each box held 200 quart baskets of fresh berries and 100 pounds of ice. The success of that venture inspired others; and two years later, on the same line, fresh beef and fish were moved, while refrigerated, in a car built especially for that service. Those pioneer efforts were not without their disappointments, and they revealed that the problem was not a simple one. Not only was it difficult to insure the uniform chilling of the entire shipment in a car, but experience brought out the fact that different perishables had different requirements when it came to refrigeration—these requirements being due to their dissimilar natures and to their variable keeping qualities even under normal conditions.

Interesting as it would be to recount how obstacle after obstacle was overcome and how refrigerator cars were gradually improved and so constructed that they would meet wide and varied demands, still we must confine our recital to a few outstanding facts that will help us to grasp the extent of the present-day service of refrigerator cars and their broad function in aiding to make us and to keep us a robust and generally contented people.

For years after refrigerator cars became more or less standardized forms of railroad rolling stock, they were used mainly for the transportation of so-called frozen meats, certain dairy products, and some of the sturdier fruits and vegetables that lent themselves readily to such handling. Gradually, the lengths of the runs were increased; and this often involved meeting temperature changes of considerable range between the loading and the unloading points of the shipments. This necessitated the creation of intermediate icing stations for the recharging of the ice bins or ice boxes in the cars and even modifications in the cars themselves.

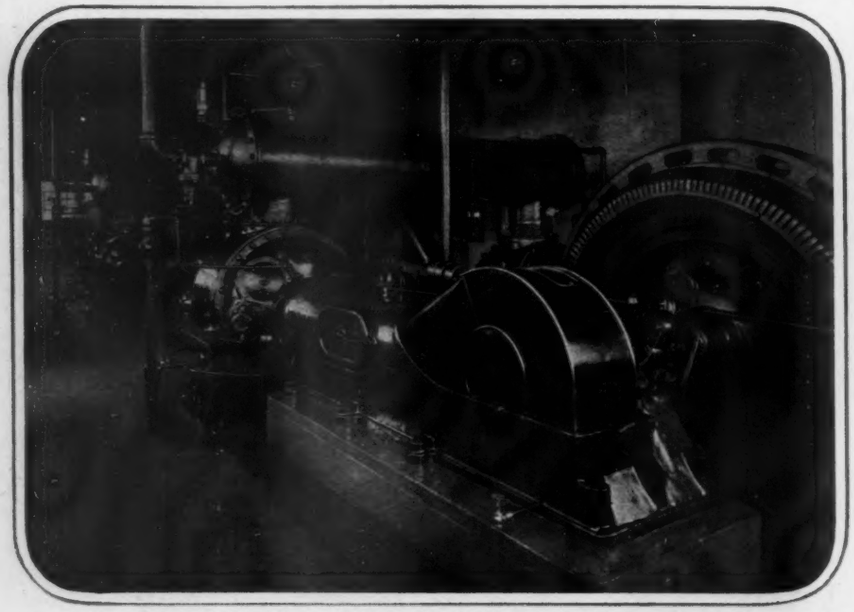
Not only that, but the longer hauls inevitably led to efforts to obtain return shipments from the remoter delivery points so as to keep the cars earning revenue the while and thus to reduce the general cost of the service. As a consequence, for example, the South began to send to the North early vegetables and fruits in return for the commodities dispatched to it from the North. Again, the favored sections of the Pacific Coast and the Southwest came to be counted upon by northern and eastern states for numerous table delicacies that their harsher climates denied them during long periods of each year. Finally, as striking evidence of the broadened service of refrigerator cars, these vehicles are now moving cut flowers thousands of miles to give color to the life of parts of the country when those sections are still in the grip of winter or their fields unawakened to the reproductive urge of springtime.

Most typically modern refrigerator cars are designed to serve a triple purpose so that they can haul perishable commodities at all seasons of the year and maintain an internal temperature that will offset the prevailing external temperature. That is to say, they are used as refrigerator cars, as ventilator cars, and as cars that may be heated suitably in cold weather by means of charcoal stoves. When used as a refrigerator car, the vehicle must be iced; when used as a ventilator car



Left—These twenty refrigerator cars represent a day's production at the East Rochester plant of the Merchants Despatch Transportation Company. Right—A fine example of a type of refrigerator car built for special service.

1—At left, underframes ready for the wooden bodies. At right, wooden bodies receiving their insulation. 2—Storage yard for the various kinds of lumber used in constructing refrigerator cars. 3—Wheel and axle shop where air-operated hoists are used extensively. 4—In the wood mill where lumber is fabricated to meet different requirements in constructing refrigerator car bodies. 5—Storage yard for steel plates, angles, and fabricated shapes that form structural features of refrigerator cars.



These two 450-cubic-foot PRE compressors provide air for many purposes in the East Rochester plant.

ice is not ordinarily necessary—the proper circulation of the air through the ventilators sufficing to keep the contained shipment cool enough; and when used as a heated car, the object is to prevent frosting or freezing of the goods by the external temperature. We see from the foregoing explanation how diverse are the services to which refrigerator cars are now put in traveling from one end to the other of the country and during all seasons of the year.

In a report made by the Bureau of Foreign and Domestic Commerce in 1923, it was stated that fresh fruits and vegetables pay more than one-third of the total freight revenue of the agricultural crops of the United States. This gives us some idea of the magnitude of the business handled by refrigerator cars; but perhaps we can get a clearer understanding of the nature and the scope of this business from certain analyses made by the Bureau of Railway Economics between 1917 and 1927. Taking sixteen of the principal fruits and vegetables for consideration, the bureau found that the average rail shipments from 1917 to 1919 aggregated 478,540 carloads annually. During the calendar years of 1924 to 1926, inclusive, the bureau tabulated the movement of sixteen fruits and seventeen vegetables in nationwide distribution over our railroads. In 1924, there were 943,932 carloads of these commodities hauled hither and thither throughout the country; during the succeeding year, 949,421 carloads; and during 1926 this tide of comestibles totaled 1,010,724 carloads! It is significant that the shipments of fruits in 1926 were 12.1 per cent greater than they were two years previously, while the increase in the volume of vegetables moved was only 2.2 per cent. Manifestly, the national appetite for fruits was growing keener and at a marked rate. Indeed, many of the fruits and vegetables, by reason of their very perishable nature, were classed as luxuries and delicacies ten or twelve years ago; but now we look upon them otherwise because of their fairly general consumption.

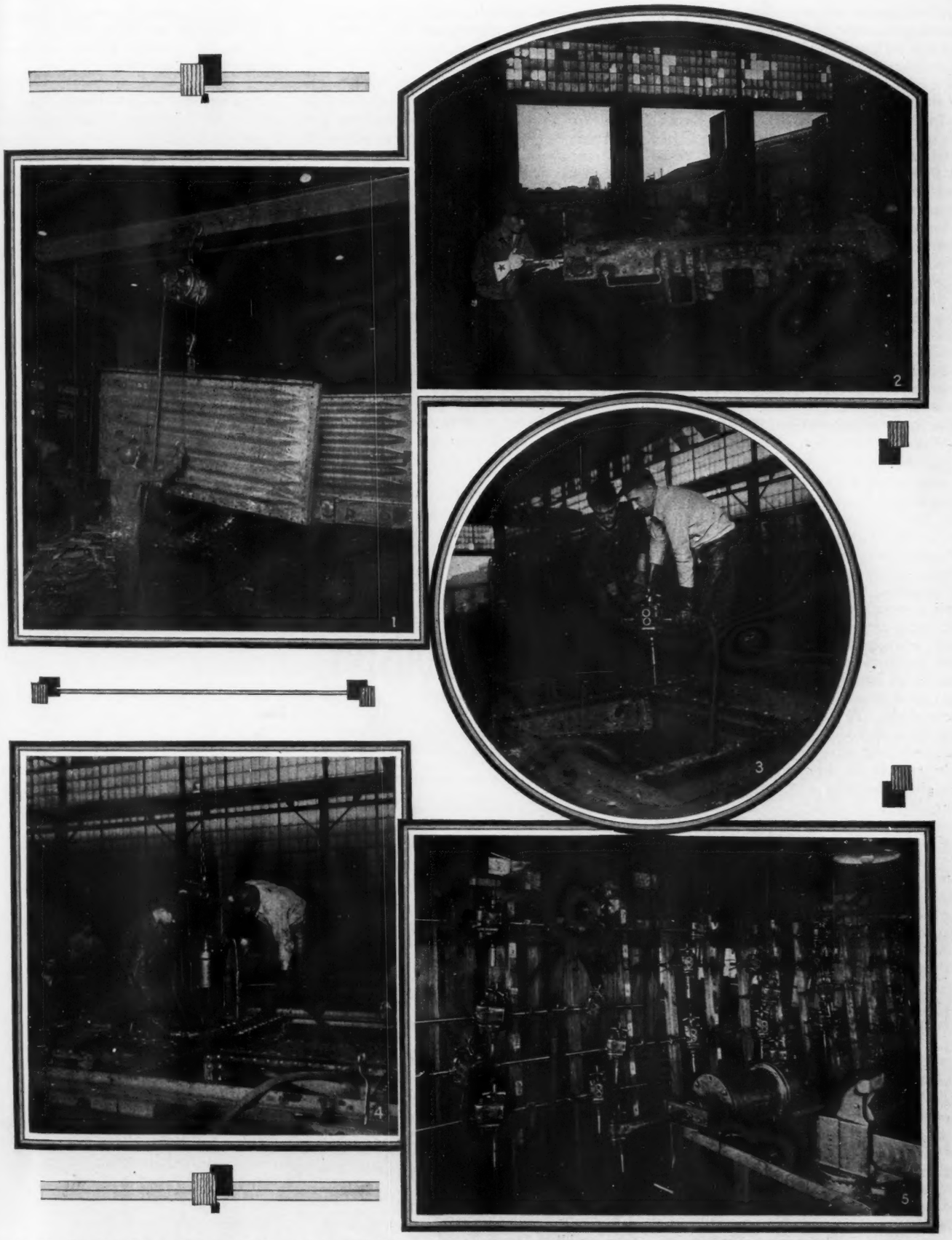
In July of 1928, the Bureau of Railway Economics issued a bulletin dealing with the number of "unloads" of fresh fruits and vegetables at 66 important consuming markets in the United States, and in that bulletin dealt with a total of eighteen commodities. These were: apples, cabbage, cantaloupes, celery, grapefruit, grapes, lemons, lettuce, onions, oranges, peaches, pears, plums and prunes, white potatoes, sweet potatoes, strawberries, tomatoes, and watermelons. The mere recital of these comestibles is enough to make the mouth water.

According to the bulletin, "From a rail-shipping standpoint, white potatoes stand first, apples second, grapes third, oranges fourth, followed in order by lettuce, watermelons, peaches, cabbage, cantaloupes, and onions. But from the standpoint of unloads in the 66 markets, the order is somewhat different. White potatoes take the lead, nearly one-fourth of the unloads in these markets being of this product. Next in line is grapes, followed by oranges, apples, lettuce, cantaloupes, watermelons, onions, cabbage, and tomatoes. These ten commodities represent over 80 per cent of the combined unloads."

In the distribution of these perishable edibles, long hauls predominate—incidentally emphasizing the importance of the refrigerator car. The produce of the farms and orchards of the Pacific Coast and the Gulf States were carried the greatest distances. To be specific: nearly 43 per cent of the California carloads of fruits and vegetables traveled more than 3,000 miles; about 35 per cent moved between 2,000 and 3,000 miles; and the 22 per cent remaining was hauled less than 2,000 miles. About 60 per cent of the products from the State of Washington was shipped between 2,000 and 3,000 miles; and 82 per cent of the fruits and vegetables from Florida traveled between 1,000 and 2,000 miles. The greater part of the products from Georgia, Minnesota, and Maine moved from 500 to 1,000 miles, while the bulk of the produce from the farms and orchards of Virginia, Wisconsin, and New York was hauled less than 500 miles. These figures are especially interesting when it is recalled that California, in 1927, furnished no fewer than 22,827 carloads of lettuce, or substantially 59 per cent of the cars of lettuce unloaded that year in the 66 markets covered by the survey.

But the foregoing data quite fails to bring home one vital economic fact—something that touches each and all of us directly, namely, that in numerous instances the fruits

The blacksmith shop is proud of the brake-beam hangers that are forged there in large numbers.



1—Air-operated hoists are used extensively in handling material in fabricating refrigerator cars. 2—Driving the last of the rivets in assembling the underframe of a refrigerator car. 3—Air-driven drill reaming holes in the steelwork of the underframe of a refrigerator car. 4—Certain of the heaviest rivets in a steel underframe are driven with an air-operated riveting machine. 5—Pneumatic tools ready for re-issue after cleaning and overhauling.

and vegetables from remote points were able to compete with similar commodities grown locally, and, besides keeping the prices stable and reasonable, made it possible to lengthen to a considerable extent the season or period of supply.

In the United States and Canada there are at the present time approximately 171,000 refrigerator cars in service; and fully 165,000 of these are owned or operated by railroads and by other concerns engaged in handling, distributing, and selling perishable foodstuffs. So much for the use of the refrigerator car. Now let us touch briefly upon their construction, as exemplified by the cars built by the Merchants Despatch Transportation Company at its plant in East Rochester, N. Y. This company constructs refrigerator cars for the Merchant's Despatch, Inc., of Rochester, N. Y., which owns and operates over the railroads of the United States and Canada more than 15,000 refrigerator cars. In the course of a year its cars travel fully 2,000,000 miles and transport about 190,000 loads of perishable commodities.

For our present purpose it is not needful to enter into a detailed description of any of these cars other than to say that their designs and their equipment—depending upon the service for which they are intended—are the outcome of many years of experience and progressive betterment. When used as mobile refrigerators, the cars must be capable of holding enough ice to do the necessary chilling over journeys of some hundreds of miles before arriving at re-icing points; and means must be provided to keep the cold air circulating so that all the commodities within them shall be maintained at a fairly even temperature. To accomplish this, each car must be so thoroughly insulated at the top, floor, ends, and sides that the ice in the end tanks can do its work with the least loss through radiation to the enveloping atmosphere.

This confinement of the cold within the car is achieved by lining the side walls with four layers of "flaxlinum" or hairfelt insulating material having a total thickness of 2 inches, the ceiling with 2½ inches of hairfelt, and the floor with 2 inches of cork in the form of slabs. The ends are variously insulated with celotex, hairfelt, and cork—an interior air space increasing the effectiveness of this insulation. The ice tanks are of the so-called basket type; and the two tanks in each car are capable of holding, when filled, 11,500 pounds of chunk ice. This is ample to refrigerate the 2,100 cubic feet of space for the storage of perishable goods.

The work at the plant of the Merchants Despatch Transportation Company covers in a general way what may be seen in any railroad car shop—differing only in those operations that distinguish a refrigerator car from other box cars built of similar materials. Even so, the construction work is necessarily standardized and, in many important particulars, specialized. The various contributive operations follow a fixed schedule, because the plant is run so that it may turn out, when operating to capacity, a given number of complete cars daily. The plant can produce 20 cars every 24 hours—such a string as one of our illustrations shows.

Compressed air is utilized in many ways throughout the plant to expedite operations and to insure satisfactory and uniform performances. Air hoists are used at numerous points to handle materials rapidly; air is employed to blow scale from the dies of the drop hammers; and air-sprayed oil heats the furnaces in the blacksmith shop. Air-driven tools do reaming, drilling, riveting, and chipping; air is used to do sand-blasting; and a considerable measure of spray-painting is done with compressed air. The floor spikes are driven with air hammers. These 60-penny spikes are 7 inches long; and, after passing through flooring 1¾ inches thick, must go successively through 2 inches of cork insulation, a ⅞-inch bottom floor, and ¼ inch of zero compound waterproofing before penetrating deeply into the underlying car sill. No wonder the vigorous blows of air hammers are needed to drive these spikes home.

Some of our readers may have been privileged to go through the interesting plant of the Merchants Despatch Transportation Company; but for the many that have not and perhaps cannot do this, we are letting our numerous photographs tell the story—thus giving them a visual conception of what goes on there while fabricating refrigerator cars.

The Trans-Canada Limited of the Canadian Pacific is to be provided this summer with a special feature in the shape of a solarium car.

Estimates reveal that the number of automobiles scrapped in the United States during 1928 reached 2,367,000. This figure is equal to 70 per cent of the new cars put to service in the country in that twelvemonth.

A 4-story building of rustless iron is attracting attention in Essen, Germany, where it was erected by the Krupp Works.

The United States Bureau of Reclamation has to its credit the building of 125 dams. These range from simple diversion dams, less than 3 feet high, to the great Arrowrock storage dam rising to a maximum height of 348.5 feet. This structure will soon be outclassed by the Owyhee Dam now under construction.

A department of highway engineering has been established at the Royal Italian Engineering School through a private gift. The donor, the head of a local highway-construction firm, has also placed his workshops and offices at the disposal of the students so that they may receive practical as well as theoretical training in roadbuilding.

It is reported from Germany that a scientist, at the Greifswald University, has found a new use for silver—namely, as an agent for sterilizing water for drinking purposes. The statement is made that 1½ grains of silver, prepared in a special manner, will destroy the germs in 10,000,000 quarts of water.

One way of making records of tests is by the use of the camera. By grouping the necessary recording instruments, such as voltmeters, tachometers, etc., on one board, and by photographing that board at definite intervals, accurate information is at all times available.

By a new system of lighting airports the lamps are set below ground and are arranged in the form of a letter T having a length of 1,000 feet. Each lamp is 8 inches in diameter; and the entire system is turned on at dusk and off at dawn by an electric time clock. In case of an emergency it can be controlled manually.

An airport of an international character is nearing completion at Douglas, Ariz., and Agua Prieta, Sonora, on the United States-Mexican border. The field covers an area of two square miles, divided about equally between the two countries.

The press reports that a system of rapid color-printing of pictures transmitted by radio has been invented. Use is made, so it is claimed, of a heat-sensitive, wax-coated paper over which is passed a hot-air brush, the jets of which are regulated by radio impulses. The hot air emanating from the brush melts the wax, making a stencil that corresponds to the original picture being transmitted. The color end of the process is not revealed.

Despite the importance of falling waters and petroleum as a source of power, coal is still producing three-fourths of all the energy now generated the world over, says Prof. W. O. Blanchard of the University of Illinois.

It is the opinion of Sir David, geologist at the Sydney University, Australia, that the world's greatest untouched coalfield lies in the Antarctic region. The existence there of large deposits of coal has been known since the time of the Shakleton and other South Pole expeditions; and scientists are looking to the Byrd party, now in that region, for a confirmation of those reports.

Oil has recently been discovered in Jugoslavia. The wells are located in the Sisek industrial region, and are said to be richer than those in the Baku district of Russia.

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EDITORIALS

RAILROADS MAKE RECORD IN ACCIDENT REDUCTION

FOR the second consecutive year, the Texas Mexican Railroad has won first prize in the competitive safety campaign that has been active since 1923. The award was made because that railroad had no accidents among its employees during the year gone; and about 47 other railroads of the same approximate size were grouped together in this competition with the successful line.

Prizes were also awarded at the same time, a few weeks ago, to six other railroads and to the Chicago Central zone of the Pullman Company owing to the excellence of their safety records. The prize-winning roads are: the Southern Railway System, with a casualty rate of 8.0; the Southern Pacific Lines, with a rate of 8.91; the Oregon-Washington Railroad & Navigation Company, with a rate of 4.63; the Chicago Great Western, with a casualty rate of 3.30; the Gulf, Mobile & Northern, with a rate of 2.15; and the Ann Arbor Railroad, with a casualty rate of 2.81. Each of the foregoing lines had fewer accidents than any other railroad in its class. The Chicago Central zone of the Pullman Company, with a casualty rate of 5.57, was the winner over seven other zones of that company. The casualty rate is calculated on the basis of the number of accidents to employees per million man-hours of work.

As a result of this safety campaign there was a reduction during 1928 of 61,479 casualties among the 177 competing railroads. The National Safety Council has estimated that 1,383 lives have been saved and 180,000 persons kept from severe injury since this invaluable competition was started six years ago. Surely, this is a splendid record.

PROBLEM OF LONGER PIERS FOR NEW YORK

PIERS one thousand feet long for certain great transatlantic liners now under construction constitute a triple problem for the port authorities of New York and New Jersey and the Engineer Corps of the Federal Government. New York City is very desirous that permission be granted to build the contemplated piers, and New Jersey and the Army Engineers are equally insistent that nothing of the sort be allowed—especially in that section of the North River where the majority of the big transatlantic liners now dock. The New Jersey port authorities and the Government engineers object to the proposed extra long piers on the score that they will narrow the channel of the North River and thus add to the dangers and the difficulties of navigating that stream—particularly under some tidal conditions.

This controversy brings to mind a similar situation about seventeen years ago when preparations had to be made to accommodate the *Olympic* and the *Titanic*, then building. The War Department set itself squarely against granting authority to add permanently to the length of the existing docks used by the line in question; and the Army Engineers gave excellent theoretical reasons for the Government's attitude. Even so, everybody interested was not convinced; and, in order to obtain practical evidence in support of the theoretical conclusions, a solution was sought in the United States Model Experimental Basin at the Navy Yard, Washington, D. C. The basin was arranged for the time being to simulate, on a much reduced scale, the flanking waterfronts along that part of the North River under consideration. Miniature docks projected outward from each make-believe shore line, and between these piers were moored models, to scale, of various well-known ocean steamships.

With the foregoing arrangements completed, a model representing on the same scale a 1,000-foot liner was attached to the basin's towing carriage. This was pulled through the water at speeds corresponding to the different speeds at which such a vessel would be likely to approach her pier in varying tidal circumstances. A moving-picture camera was employed to photograph not only the position of the towed model but the surface and subsurface disturbances of the water set up by the advance of the simulated 1,000-foot steamship. A number of ingenious devices were utilized to render these perturbations visible. Those classic experiments established impartially and beyond dispute that further narrowing of the North River would invite serious reflexes that might at times gravely hamper if not endanger the operations of river and harbor traffic.

Undoubtedly, the Army Engineers are fully alive today to the revelations of those towing experiments that were concluded early in 1913. Their attitude is understandable, because additional encroachments upon the tidal prism would inevitably augment tidal velocities during the inbound and the outgoing sweep of the water so bottle-necked. One has only to recall that when the ocean sends its flood tide inland up a river it arbitrarily fixes the volume of water that must be received and accommodated at that time. This volume must reach its equilibrium of distribution within the hours set for the flood-tide movement, and, conversely, when the sea recedes, the ebb flow, plus increments from tributary streams and springs and, possibly, rainfall, must travel oceanward to the point of low tide within the number of hours established by Nature's forces. Accordingly, the volume of water flowing through a restricted pathway must move at a higher speed than where the right-of-way is wider and progress becomes more leisurely. In brief, whenever man interferes with the normal movement of tidal waters he invites consequences for which he must pay. When those waters are much used by shipping of many sorts the consequences of increased current velocities are apt to impose operating penalties and possibly to promote accidents.

POOR INVENTOR REAPS RICH REWARD

ABOUT twenty-five years ago, GEORGE CAMPBELL CARSON, a nomadic Western miner, conceived an improvement in reverberatory furnaces for the smelting of metals; and, believing his invention to have practical value, he scraped together funds enough to prosecute his claims and to obtain a United States patent. Not long after the granting of that patent CARSON began to realize that his efforts had brought him seemingly only a "deed to trouble".

He could not sell his rights for any sum that was commensurate in his eyes with the value of his improvement in such furnaces; and to make the situation more ironical he discovered that his invention was actually being used by metallurgical companies of outstanding prominence. Years went by and still he could not obtain monetary satisfaction for that appropriation of his invention; and his resources were too meager to enable him to drag his fight through the tedious course prescribed by the laws of the United States. CARSON would probably be hard up even today had his luck not taken a sharp turn for the better.

Two San Francisco men of wealth responded to the inventor's appeal, and organized the Carson Investment Company that has had for its primary purpose the prosecution of CARSON'S claim to priority and to bring about settlements with the different companies that were said to be infringing his patent. Thus money was provided to pay competent lawyers to fight CARSON'S cause; and, so fortified, the case was carried all the way to the Supreme Court of the United States, where a decision in favor of the inventor was won. Since then, CARSON'S attorneys have been busy obtaining settlements in his behalf. Even though the erstwhile "desert rat" owns less than a quarter of the capital stock of the Carson Investment Company, he is said now to be the richer by

several million dollars because of the activities of that company. The point is that without the support so obtained he would probably still be woefully short of funds.

It would no doubt interest the public to learn how much was spent by the investment company in order to establish the validity of CARSON'S patent and then to see to it that he was rewarded for the use of his invention. But, without this knowledge, it must be evident, to any one familiar with such procedures, that CARSON would in all probability be penniless today despite his inventive cunning had men of means not come to his aid. Manifestly, there is something wrong with a patent system that makes such a situation not only possible but all too often likely.

TACNA-ARICA DISPUTE NOW SETTLED

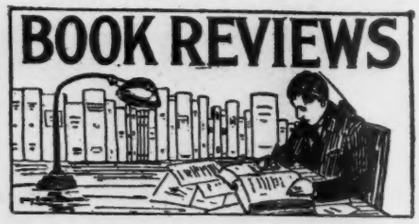
ALL the world, and especially the Western Hemisphere, should find ample reason for rejoicing in the settlement of the Tacna-Arica problem that has been a source of irritation and even bitterness between Chile and Peru for a period of 46 years. Time and again, the dispute concerning the territory involved has been a cause of great anxiety owing to the fact that on various occasions the two countries immediately affected were on the verge of open hostilities. Thus, for the better part of five decades, Tacna and Arica continued to be potential fuel for the flame of war, and to that extent a thorn in the side of peace.

Now happily the situation has changed, and Chile and Peru start upon a new era of neighborly understanding that will inevitably prove a boon to all nations by setting an example of amicable adjustment of a vexed question instead of resorting to force of arms as the arbiter. In this splendid example of the workings of American diplomacy the United States has played a persuasive part through the continual exercise of its good offices whenever the delicate situation permitted. Recognition of this appears in a recent interview between Pres. WASHINGTON LUIS of Brazil and a representative of *The New York Sun*. President LUIS said:

"The part that the United States took in the settlement of the dispute was entirely disinterested. For nearly half a century this dispute caused friction and discontent, which was disquieting to the other nations of South America as well as those directly involved. Through all the years the United States patiently used its good offices. We share satisfaction with Chile and Peru that the vexed question has been finally settled, and believe that the United States' mediation, through President HOOVER, is deserving of the highest praise."

CORRECTION

In our May issue on Page 2762 we printed an article entitled, *Simplifying Air-Lift Calculations*. In the third paragraph the author mistakenly gave the submergence figures of 300 and 340 feet instead of the corresponding air-pressure figures of 130 and 146 pounds.



STANDARDS YEARBOOK, 1929. A work of 401 pages, compiled by the National Bureau of Standards, and published by the United States Government Printing Office, Washington, D. C. Price, $1.00.

THIS is the third issue of an annual dealing especially with what has been accomplished through standardization both in America and abroad. Standardization has done much towards increasing efficiency and economy in numerous departments of our national life, and what has been achieved is suggestive of the possible widening of the scope of such betterments Because of the topics covered and the condensed way in which each is treated, the present volume has much to commend it.

NEW JERSEY, editor-in-chief, Floyd W. Parsons. A copiously illustrated volume of 404 pages, published by the New Jersey State Chamber of Commerce, Newark, N. J. Price, $3.50.

THIS volume is a comprehensive but withal a brief summing up of the vital story of the life, the industries, and the resources of the State of New Jersey. It is dedicated primarily to the citizens of that state; but the recital should be of interest to the people not only of the contiguous states but of those other sections of the country that have various worth-while reasons for keeping New Jersey in mind. The book serves to focus attention upon the historical background of the state as well as upon the extremely diversified character of its industries and its resources.

THE ELEMENTS OF PRACTICAL MECHANICS, by Charles Ranald MacInnes, Ph.D., Professor Princeton University. An illustrated book of 131 pages, published by D. Van Nostrand Company, Inc., New York City. Price, $2.25.

THIS book is the outgrowth of long experience in the classroom, and as a result the author has stressed two things in dealing with his subject. As he explains: "One of these is the desirability of developing graphical methods parallel with analytic ones. The second is that it is much better to develop the ideas of mechanics by illustrative examples than by a general discussion of them in the abstract." The treatment presupposes a knowledge of the calculus, but not to any extent a knowledge of mechanics

WEATHER, by E. E. Free and Travis Hoke. An illustrated volume of 337 pages, published by Robert M. McBride & Company, New York City. Price, $3.00.

IN their opening chapter, the co-authors state: "The most remarkable fact about the weather is that it exists." On the other hand the prevailing attitude of the public is a questioning one that asks continually: "What will the weather be?" The answer to this query is the one that absorbs the forecaster 90 per cent of the time; and his prognostication will be right or wrong depending upon the scope of the meteorological data for the time being at his disposal and how he interprets that information. The probability of weather changes concerns not only our personal comfort but a great many business undertakings involving the risking of much money. This explains why weather reports are watched continually; and in between the frequent publication of these reports the local weather bureau is besought for guidance.

The present book deals with this ever-changing subject in a way tha makes it informative and entertaining to the layman, and it stresses the human aspect of our modern scientific knowledge of the weather and the conditions affecting it.

IRON AND STEEL TECHNOLOGY IN 1928. An illustrated work of 353 pages, published by the American Institute of Mining and Metallurgical Engineers, New York City. Price, $3.00.

THIS volume contains papers presented before the Iron and Steel Division at two meetings during 1928; and mention of some of the titles will serve to indicate the broadness of the field covered by the papers. For example: Significance of the Simple Steel Analysis; Improvement in Blast-Furnace Construction; Utilization Problems of Metallurgical Limestone and Dolomite; Effect of Temperature on the Solubility of Iron Oxide in Iron; Steel for Aircraft Construction; The Manufacture of Some Foreign Rails; The Constitution of the Iron-Silicon Alloys, etc., etc. This volume should be of value to persons interested in the metallurgy of iron and steel as well as in the heat treatment and the use of those metals.

SPEECH AND HEARING, by Harvey Fletcher, Ph.D., Acoustical Research Director, Bell Telephone Laboratories, Inc. An illustrated volume of 331 pages, published by D. Van Nostrand Company, Inc., New York City. Price, $5.50.

THE present volume crystallizes work, extending over a period of substantially sixteen years, initiated by the Research Laboratories of the Bell Telephone System in an effort to obtain the fundamental facts on speech and hearing in order to have certain definite knowledge upon which to base the design of apparatus and systems for telephone use.

The subject, apart from its intimate and indispensable identification with our everyday life, is a fascinating one; and the author's treatment of it is both lucid and absorbing. The book contains a wealth of valuable data.

The Mining Handbook of Canada is the title of a booklet issued by Arthur E. Moysey & Company, Ltd., New York and Toronto. It is a helpful compendium of authoritative information concerning the mining properties and districts of Canada.

Economic and Industrial Switzerland. This illustrated booklet, published at Lausanne by the Swiss Office for the Development of Trade, is in English and contains a great deal of data upon the industrial life of that bustling and progressive country.